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Journal of

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Journal of
PROFESSIONAL PRACTICE
Proceedings of the American Society of Civil Engineers

SIX THOUSAND HIGH SCHOOL STUDENTS VIEW ENGINEERING AND SCIENTIFIC CAREERS[a]

Report of the Student Activities Committee, San Diego Section, ASCE
(Proc. Paper 1868)

SYNOPSIS

For the past few years, our national professional engineering societies have expressed increasing concern over the engineering student shortage in our country. As a means of investigating, at the high school level, the reasons for this shortage, a questionnaire was prepared by the Office of the County Superintendent of Schools at the instigation of the Student Activities Committee of the San Diego Section of A.S.C.E. and administered to approximately 6,500 high school students of San Diego County. The purpose of this report is to present the results of these questionnaires and to evaluate some of the reasons for the lack of interest in the scientific fields among our high school students.

INTRODUCTION

By letter of November 3, 1954, the Executive Secretary of A.S.C.E. transmitted to the local sections a report of the Engineering Manpower Commission and the Scientific Manpower Commission Joint Committee on High School Teachers of Science. The Secretary suggested that all local sections implement to the best of their ability the recommendations of the Joint Committee. The Joint Committee's report stated that emphasis should be placed upon two important questions:

1. What can be done to assist high school teachers of science and mathematics who are already teaching and thus encourage them to continue in such teaching?
2. What can be done to increase the supply of adequately trained high school science and mathematics teachers?

Note: Discussion open until May 1, 1959. To extend the closing date one month, a written request must be filed with the Executive Secretary, ASCE. Paper 1868 is part of the copyrighted Journal of Professional Practice Division, Proceedings of the American Society of Civil Engineers, Vol. 84, No. PP 1, December, 1958.

a. Presented at the February, 1958 ASCE Convention in Chicago, Ill.

The Secretary's letter of transmittal and the Joint Committee's report were referred to the Student Activities Committee of the San Diego Section for review and recommendation.

The Student Activities Committee agreed that these were important questions and to that end has guided the San Diego Section in a cooperative program with other professional engineering societies to assist the schools in answering these questions satisfactorily. Assistance has been rendered by providing career-day speakers from Section membership; cooperating in sponsoring science fairs; providing speakers for special school events; extending to science and mathematics teachers and their outstanding students invitations to dinner meetings during National Engineers' Week; providing engineering counseling to high school students interested in engineering; and making available to students copies of professional engineering magazines and other technical literature.

In its report to the Section, the Student Activities Committee expressed the opinion that although the activities listed above were helpful, it appeared that further basic information on problems affecting the supply of engineering and scientific manpower would be desirable. It further occurred to the Committee that one source of basic information was in the thinking and attitudes of the high school students themselves. Although much had been said by educators, industrialists and engineers regarding their opinions on this matter there appeared to have been little work done in approaching the high school students directly in an effort to determine why they are not pursuing courses to qualify them for scientific and engineering studies at the college level.

With this thought in mind, the Student Activities Committee proposed that a survey by questionnaire be made of high school students in the San Diego County Schools in order to determine their attitudes regarding choice of an occupation after completion of their high school courses. This proposal was made with the thought that basic information pointing to necessary corrective measures could be obtained. It was believed that the information could be of value to educators. The San Diego Section approved this proposal and authorized the Student Activities Committee to proceed with the project and to seek the cooperation of the San Diego County Superintendent of Schools.

The Schools

There are 15 high schools within the County of San Diego outside of the City of San Diego. All of these were included in planning of the program and all except two of the smallest districts participated. Those participating ranged in size from 203 to 1952 students. Four schools had an average daily attendance figure of less than 500. Five schools had an average daily attendance figure of over 1,000. Eight of the schools taught classes in grades from 9 through 12. Five of the schools taught classes in grades from 10 through 12.

The participating schools represent an entire cross-section of development ranging from small villages surrounded by extensive agricultural communities to highly developed, residential areas adjacent to the City of San Diego.

QUESTIONNAIRE ON VOCATIONAL INFORMATION
for Senior High School Students
San Diego County

Name of School _____

Check One: Boy ☐ Girl ☐

Check Grade in School: 10 ☐ 11 ☐ 12 ☐

Check Average of Grades in High School Subjects: A ☐ B ☐ C ☐ Below C ☐

Age: _____

Father's Occupation: _____ Mother's Occupation: _____

1. Name the occupation in which you are now most interested: _____

	YES	NO
2. Do you think your present high school program will help you in your chosen occupation?	___	___
3. Have you watched or worked with someone in this job?	___	___
4. Do you feel you have enough information about this occupation in terms of:		
a. Salary	___	___
b. Training	___	___
c. Security	___	___
d. Working conditions	___	___
e. Chance for advancement	___	___
f. Chances for employment	___	___
5. Did the following items influence you to choose the occupation:		
a. Parents or friends	___	___
b. Pay	___	___
c. Working conditions	___	___
d. Subjects required are easy	___	___
e. Liking for a particular subject	___	___
f. Have watched people at work in this job	___	___
g. Have had some work experience in this field	___	___
6. Do you know what subjects in high school will help you in this occupation?	___	___
7. Do you think the high school should give more training in other occupations?	___	___
8. Have you had a chance in school to find out about other occupations?	___	___
9. Are you interested in having information about other occupations?	___	___
10. If your occupational choice was in a field other than science or engineering, was it because:		
a. You do not know enough about science and related occupations?	___	___
b. They are too difficult	___	___
c. Job opportunities in science and related occupations are not great enough	___	___
d. They do not pay enough	___	___
e. You do not enjoy studying science	___	___
f. You do not enjoy studying mathematics	___	___
g. Not enough scholarships are available to students interested in science and related occupations	___	___
h. Not enough science courses offered in high school	___	___
i. I like other subjects better than science	___	___
11. Have you listed your chosen occupation only because you needed one to answer this questionnaire?	___	___

EXHIBIT I
SHEET 1 OF 2

12. For the subjects you enjoy most, check "Yes"; for subjects you enjoy least, check "No". You need not check all subjects

	YES	NO		YES	NO
Art	___	___	Industrial Arts	___	___
Biology	___	___	Journalism	___	___
Business Courses	___	___	Mathematics	___	___
Chemistry	___	___	Music	___	___
Dramatics	___	___	Physical Education	___	___
English	___	___	Physics	___	___
Foreign Language	___	___	Social Studies	___	___
Health	___	___	Speech	___	___
Homemaking	___	___			

13. Check the subjects you think will be of help in the vocation of your choice:

Art	___	___	Industrial Arts	___	___
Biology	___	___	Journalism	___	___
Business Courses	___	___	Mathematics	___	___
Chemistry	___	___	Music	___	___
Dramatics	___	___	Physical Education	___	___
English	___	___	Physics	___	___
Foreign Language	___	___	Social Studies	___	___
Health	___	___	Speech	___	___
Homemaking	___	___			

14. Describe briefly your opinions concerning your occupational choice listed in Question 1. Be as specific as possible.

a. Duties: _____

_____

b. Average salary: beginning _____ maximum _____

c. Working conditions: _____

_____

d. Chances for advancement: _____

_____

e. Training needed: _____

_____

15. Other occupations in which I am interested are: _____

_____

16. Are you interested in vocations in the field of education? Yes ____ No ____

a. If answer is "yes," give type of job and subject area of most interest to you:

_____

b. If answer is "no," give reasons: _____

_____

EXHIBIT 1
SHEET 2 OF 2

The Questionnaire

The Office of the San Diego County Superintendent of Schools received the proposal of the Student Activities Committee with enthusiasm and gave wholehearted cooperation. Several meetings were arranged between the schools' administrative personnel and the members of the Committee. Discussions at these meetings led to the preparation of a list of questions to be submitted to the high school students. This list was prepared in final form by the school staff and reviewed by the Committee. The questionnaire as finally evolved and submitted to the students is shown as Exhibit 1. In general, the questionnaire, being of the forced choice type, investigated two areas of thought insofar as the students were concerned. They were:

1. Do you have enough information at your disposal to make an intelligent choice regarding your future occupation?

2. If your occupational choice was in a field other than science or engineering, what was the basis for your decision?

These questions were asked directly and indirectly by the use of check questions for establishing the sincerity and consistency of the students' answer to the questionnaire.

The questionnaire was then administered to cover 10th, 11th and 12th grade students in the San Diego County schools as above described. For uniformity, the 9th grade was not questioned since not all of the senior high schools had this grade. This was accomplished in April and May of 1956. The questionnaire was completed by 6,597 students in 13 high schools. To preserve anonymity names were not affixed to the questionnaire.

After a random sampling of 500 samples of the questionnaire by school staff for their own purposes, the remainder were given to the Committee. The results reported herein are based upon analysis of all of the answers.

Tabulation of Results

For the purpose of segregating and classifying the answers the scientific occupations were defined as those which require graduation from a four year college or university course with a substantial amount of work in mathematics and physical or life science and which required the ability to work on individual initiative with a minimum of supervision. This category included but was not limited to the following:

Astronomy
Chemistry
Engineering (all branches)
Forestry
Geology
Mathematics
Medicine (including Veterinary)
Physics
Science teaching

This category did not include drafting, laboratory technician, law, nursing, and non-scientific teaching.

Further segregation was made by means of the students' performance in

high school as indicated by his grade average. The following divisions were used:

A and B defined as Above Average
B-minus and C defined as Average
C-minus and below defined as Below Average

Other groupings were by grade in school and sex.

Questionnaires totalling 470 in number, which omitted any one of the answers necessary to segregate them as described above were not used in the tabulation summary. The question unanswered the greatest number of times was that pertaining to the average grades in high school subject, which occurred 188 times. One hundred sixty students declined to indicate an occupational choice.

The tabulation of answers to the questions asked on some 6,000 questionnaires was obviously a job of considerable magnitude from the standpoint of manhours. The cost involved to do this work by machine methods or employment of additional help far exceeded the Section's budget for this project. The cooperation of some 50 members of the San Diego Section was cheerfully given for the purpose of tabulating the results of this questionnaire. The final consolidation of the tabulation was performed by members of the Committee.

Results

The results of the tabulation of answers to the questionnaire are illustrated graphically by means of the bar charts (Figs. 4 to 52) of the Appendix. In order to point out briefly some of the interesting conclusions which have been drawn by a more detailed study of these bar charts, the following explanations and summaries for a number of the questions asked are given below. For the groups as a whole, boys and girls numbered approximately equal with 2,815 boys and 2,812 girls submitting answers to the questionnaire. By grade in school the tabulation was as follows:

	Boys	Girls
10th Grade	1,185	1,166
11th Grade	903	961
12th Grade	727	685

Inasmuch as the boys were the only group showing a substantial interest in the scientific field, the following discussion is limited to boys only.

Boys

36 percent of all the boys rated themselves as being in the Above Average group (A and B). Of those indicating an occupational preference in one of the scientific fields, 63 percent considered themselves to be in the Above Average group.

The percentage of students who showed a preference for occupations in the scientific and engineering fields was practically constant at 25 percent for each of the three grades.

A discussion of the questions and answers follows: The first question stated "Name the occupation in which you are now most interested." This answer was used to segregate the questionnaire returns into science and

non-science categories as previously discussed. The subsequent questions all referred to the answer given to the first question.

"Do you think your present high school program will help you in your chosen occupation?" Students in nearly all divisions (segregation by school performance) believed their high school programs would help them in their chosen occupation. More students with Above Average records felt so than did those in the other two divisions. More students with science interests felt so than did those with a non-science interest. Of the students with science interests in the Above Average division approximately 95 percent believed their high school program would help them in their chosen occupation. The twelfth grade students with non-science interests and Below Average records believed their high school program would not help them in their occupation. Only 39 percent of those falling in this division believed otherwise. This compares with a figure of 54% for boys with non-science interests and Below Average records in the eleventh grade.

"Have you watched or worked with someone in this job?" Approximately two-thirds of the students with a non-science occupational preference had watched or worked with someone in the job chosen. A greater percentage of the students with lower school records indicated "on the job" experiences than did the Above Average students. In the science interest occupational preferences only about one-third of the students indicated "on the job" experiences.

"Do you feel you have enough information about this occupation in terms of salary?" About 60 percent of all students in the non-science interest categories believed they had sufficient information regarding the salary of the chosen occupation. The percentages for the science interest categories ran approximately the same with an increase to 75 percent for the twelfth grade Above Average students.

"Do you feel you have enough information about this occupation in terms of training?" About 60 percent of all students in the non-science interest categories believed they had sufficient information regarding their chosen occupation in terms of training. The percentages for the science interest categories was approximately the same for grades 10 and 11 but there was an increase in the 12th grade for the Above Average students to 75 percent.

"Do you feel you have enough information about this occupation in terms of security?" The answers to this question for all occupational categories indicated that the students had least information on this particular aspect of the occupation. The percentages of those believing they have sufficient information range from a low of 49 percent for the non-science interest categories of Below Average eleventh graders to a high of 73 percent for the Above Average seniors with science interests.

"Do you feel you have enough information about this occupation in terms of working conditions?" The answers to this question indicate a greater knowledge of this aspect of the occupation than of the others examined. In the non-science categories, between 64 and 78 percent of the students believed they had sufficient information on this subject. There was less certainty among the science interest categories, the percentage of "yes" answers ranging from 44 percent for the Below Average sophomores to 76 percent for the Above Average seniors.

"Do you feel you have enough information about this occupation in terms of chance for advancement?" Students in all categories believed they had sufficient information on this aspect of the occupation. For the non-science interest categories, the percentage of "yes" answers ranged from 58 to 72. For the science interest categories, the percentages ranged from a low of 56 percent to a high of 78 percent for the Above Average seniors.

"Do you feel you have enough information about this occupation in terms of chances for employment?" For the non-science interest categories, the percentages of "yes" answers followed closely those for the previous question. The science interest category appeared to have adequate information on this aspect, the "yes" answers ranging from a low of 58 percent to a high of 86 percent for the Above Average Seniors.

"Did the following items influence you to choose the occupation-parents or friends?" There were substantially more "no" than "yes" answers to this question, in all categories. No pattern could be established for appreciable differences between the various grade and achievement groups or between the science and non-science interest categories.

"Did the following items influence you to choose the occupation-pay-?" Less than half of every group in the non-science interest categories answered "yes" to this question. This was reversed in the science interest category with the majority of all groups answering "yes." The highest percentage of "yes" answers was 71 from the Above Average senior boys.

"Did the following items influence you to choose the occupation-working conditions - ?" Working conditions appear to be a strong influence in the choice of occupation. In the various non-science interest groups, the percentage of "yes" answers ranged from 51 to 66 percent. In the science interest groups the range is greater, being 45 percent for the Average and Below Average sophomores and 72 percent for the Average seniors.

"Did the following items influence you to choose the occupation-subjects required are easy - ?" This was indicated to be the least influential factor in students' decision for both the non-science and science interest categories. The greater percentage of "yes" answers to this question (25 percent) came from the eleventh grade Below Average boys with non-science interests.

"Did the following items influence you to choose the occupation - liking for a particular subject - ?" This was indicated to be the strongest factor in selection of occupation in all groups. The smallest percentage of "yes" answers, 61 percent, came from the Below Average eleventh grade students with non-science interests. The highest percentage of "yes" answers, 91 percent, came from the Above Average junior students with science interests. The greatest percentages of "yes" answers came from the Above Average students in all grades and the lowest percentage came from the Below Average students.

"Did the following items influence you to choose the occupation - have watched people at work in this job - ?" This was a very strong factor for the non-science categories with 62 to 83 percent of the students answering "yes". The greatest percentages of "yes" answers came from the Below Average students. The range was 29 to 49 percent for the science categories.

"Did the following items influence you to choose the occupation - have had some work experience in this field - ?" Approximately half of students with non-science interests answered "yes" to this question. From this group the lowest percentages of "yes" answers came from the Above Average students and the highest percentage from the Below Average students. In the science interest categories the range of "yes" answers was from 18 to 28 percent.

"Do you know what subjects in high school will help you in this occupation?" An overwhelming majority of all students believed they knew what subjects would help them in their occupations. The percentage of "yes" answers ranged from 59 to 83 percent for the students with non-science interests and from 89 percent to 96 percent for the students with science interests. In each of the fields for all grades, the Above Average students gave a higher percentage of "yes" answers than did the Average or Below Average students.

"Do you think the high school should give more training in other occupations?" Approximately 75 percent of all students indicated a "yes" answer to this question.

"Have you had a chance in school to find out about other occupations?" Most students in all groups believed they had had opportunities in school to find out about other occupations. The range of "yes" answers was from 67 to 92 percent with no pattern being apparent.

"Are you interested in having information about other occupations?" Students in all groups indicated an interest in information regarding other occupations, but a great spread in percentage of "yes" answers is indicated. The range of percentages is from 45 to 85 percent. The lowest percentage was for Below Average sophomores with science interests. The highest percentage was for the Average seniors with science interests.

"If your occupational choice was in a field other than science or engineering, was it because: (Students were asked to check "yes" or "no" to each of 9 parts to the above question.) Obviously, this question was to be answered only by students of a non-science occupational choice. A majority indicated that: (1) they knew enough about science and related occupations to make a decision; (2) that the work was not too difficult; (3) that they did not enjoy studying science subjects; (4) that they did not enjoy studying mathematics; (5) and that they believed enough science courses were offered in high school. A strong majority believed that: (1) job opportunities in science and related occupations are great; (2) that those jobs pay enough; (3) that enough scholarships are available to students interested in science and related occupations. By a ratio of approximately 5 to 1 those students said they liked other subjects better than science. The Below Average students in each grade showed this dislike for science subjects more than the Average students; the Above Average students by a smaller percentage than the Average students.

"Have you listed your chosen occupation only because you needed one to answer this questionnaire?" Among the students with non-science interests the answers were in the negative by a ratio of 6 to 1. Among those indicating an occupation in the scientific field the answers were in the negative by the ratio of 11 to 1.

Girls

55 percent of all the girls rated themselves as being in the Above Average (A and B) group. Of those indicating an occupational preference in one of the scientific fields 88 percent indicated that they were in the Above Average group.

The percentage of girl students showing a preference for occupations in the scientific and engineering fields started at 5.7 percent in the sophomore year, decreased to 4.0 percent in the junior year, and to 3.5 percent in the senior year.

The girls in the various groups answered most of the questions along the same patterns as the boys did.

A major exception was on knowledge of salaries, where the girls indicated a lesser knowledge of this aspect of occupation information than the boys had done.

They also indicated less knowledge regarding job security and chances for advancement.

The amount of pay had even a smaller influence in the girls' choice of occupation than the boys' choice.

Fewer girls indicated that previous work experience had affected their choice of occupation.

A greater percentage of the girls indicated that they did not enjoy science and mathematics courses.

Liking of the related school subjects for the girls, as for the boys, appeared to be the greatest single factor influencing the students' choice of occupation.

Discussion

The majority of the students believed that their high school courses were laying the ground work needed for their chosen occupation. The above average students held this belief more strongly than those with lower grades. The students with a science interest appeared to better understand where they were going and what it took to get there. Only the students in the graduating class with a non-science occupational interest and a low average scholastic record believed their school courses would not help them in their occupations. It would appear that this is a natural attitude for persons in this category.

A substantial percentage of students indicating a non-science occupational interest had observed or performed work with someone on similar work, whereas the science-interest student indicated less "on the job" experience. This may be explained since the required qualifications for assisting in the scientific fields are greater than in the non-scientific field. In the non-science fields a greater percentage of those with lower scholastic records had experienced "on the job" training than did the above average students. Possibly the students' lower scholastic grading could be attributed to the outside work. Most of the students in all categories believed that they had sufficient information regarding salary levels in their chosen occupations. Their estimated starting and maximum salaries indicated that they were reasonably well informed on this point.

The majority of the students believed they had sufficient information concerning required training, working conditions and opportunities for advancement in the occupation selected. Answers to specific questions indicated that their knowledge was adequate. In examining the influencing factor in the

students' choice of occupation, the indication was that the ease of subjects was the least important factor in this choice and that the interest in the subject was the greatest factor. It is not possible, from the information provided on the questionnaire, to determine if their interest in a subject stems from particular aptitudes in a given field of study, or if it springs from superior teaching in that particular field. In this connection, it may be indicated that for the boys the percentage selecting a science related course, the choice remained nearly constant throughout the three years of senior high school study. This would indicate that the high school courses of study hold the interest of those who at the start of their sophomore year have the prerequisites required to work in a science related field. It is, of course, recognized that the sampling in each of the three grades represents entirely different groups of individuals and that there is some changing of occupational interest of individual students from time to time. The evidence tends to show, however, that most decisions have been made before the student completes the 10th grade and it would appear, then, that the place for creating interests in the science and mathematics courses is prior to the sophomore level. The large majority of the students expressed the opinion that they knew which subjects would help them in their chosen occupations. A review of the subject check lists for those indicating a science related interest showed that this was substantially correct.

The results indicated that, so far as it affected an occupational choice, pay was not a major factor. Those selecting a non-science interest indicated that it was not because of low pay in the scientific fields. The Above Average seniors who had selected a science related occupation indicated a greater knowledge regarding salaries than did any of the other groups. Interest in science related occupations was confined in large part to the boys. Their answers indicated that 25 percent of those questioned were interested in such occupation. This percentage held constant for each of the three grades. The percentage of girls with a science interest varied from 5.7 percent for sophomores to 3.5 percent for seniors. The girls indicated an interest in a great variety of occupations including teacher, secretary, typist, beautician and model. About 5% listed "housewife" as their chosen occupation. Their relatively low interest in the science field appears to be the result of their own dislike for subjects in the field leading to this type of work. It should be apparent, then, that unless some constructive steps are taken to stimulate interest, very few girls will gualify themselves for work in the scientific and science related fields.

CONCLUSIONS

The conclusions herein presented are based upon the students' answers to the questionnaire. It has been the intention of the Committee to restrict these conclusions to those which may be supported by the data as obtained from the students and presented in the Appendix to this report. These conclusions are:

1. A large majority of students (97.4%) were able to make an occupational choice.

2. The stimulation of occupational interest takes place prior to the tenth grade.

3. The majority of students believed that they were adequately informed on the various aspects of occupational choice as measured by the questionnaire.

4. For the boys, the proportion of students with science interests remained constant at 25 percent through senior high school, although there may have been some change in occupational choices by individual students. For the girls, the science interest declined from 5.7 percent for the sophomores to 3.5 percent for the seniors.

5. The students stated that a liking for a particular field of study was the principal factor in influencing their occupational choice.

6. The students indicated that a dislike for science and mathematics courses, rather than insufficient employment opportunities, inadequate salaries or too few scholarships was the greatest deterrent to the selection of a science-related occupation.

Respectfully submitted,

Leslie A. Clayton
Loy L. Flor
Robert W. Floyd
Donald A. Hoffman
Lloyd G. Jefferies
J. Frank Jorgensen
Bert C. Wilkas, Chairman

Student Activities Committee,
San Diego Section, ASCE

ACKNOWLEDGMENTS

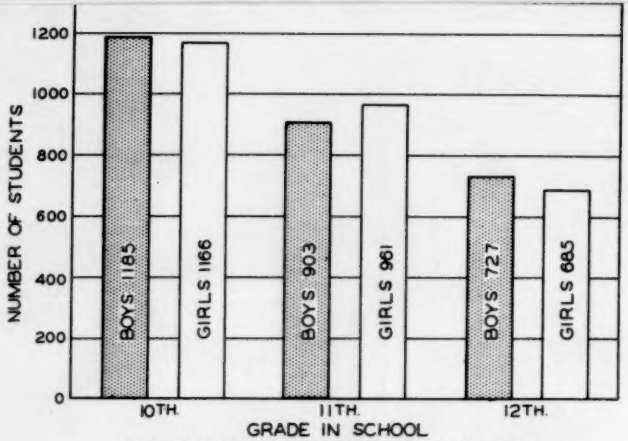
The committee is indebted to the staff of the Superintendent of Schools of San Diego County who worked closely with the Committee from the conception of the undertaking. Particular acknowledgment is made to Mr. DeGroff Platte and Dr. Virgil Howes who developed the questionnaire, served as liaison to the schools and reviewed this paper. Thanks is expressed to the principals and teachers of the schools without whose help this study would not have been possible.

Much credit is due the San Diego Section members for their work in performing the required tabulations and for their financial support to this study. The assistance and encouragement of the Board of Directors for the past three years has been most helpful and is greatly appreciated.

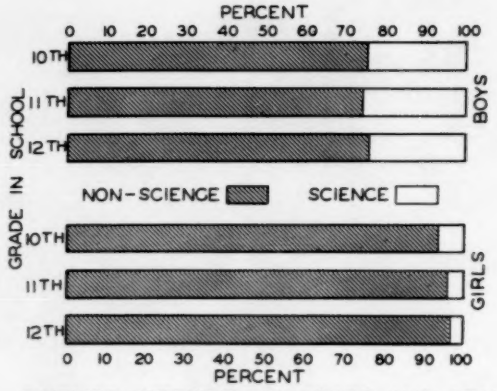
Thanks is expressed to the San Diego Lithograph Company, an affiliate of San Diego Blue Print Company, which provided the reproductions of the original test and figures.

APPENDIX

Figures 1 to 52. Charts showing all basic data derived from the questionnaires.



DISTRIBUTION BY GRADE AND SEX



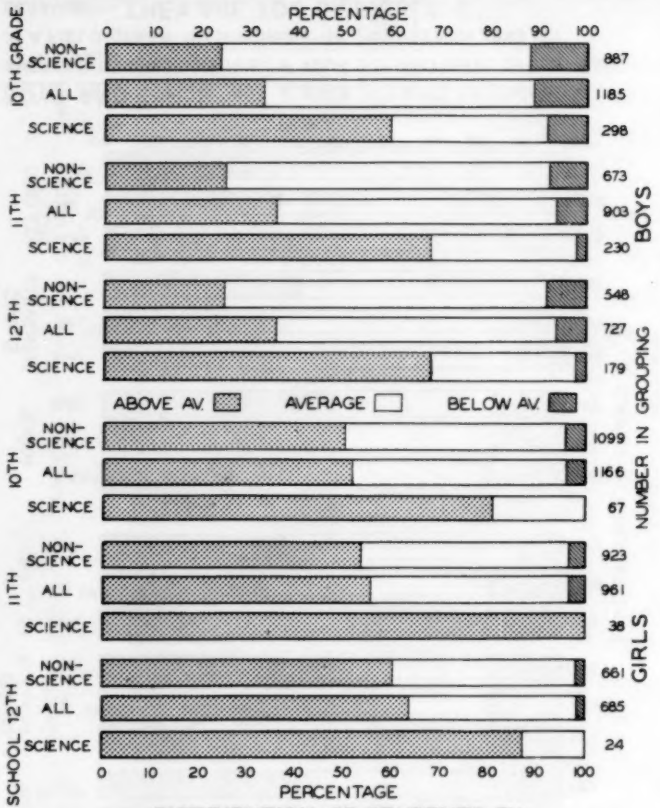
SCIENCE INTEREST BY GRADE AND SEX

FIG. 1

1955-56 A.D.A. (AVERAGE DAILY ATTENDANCE) SAN DIEGO COUNTY HIGH SCHOOLS

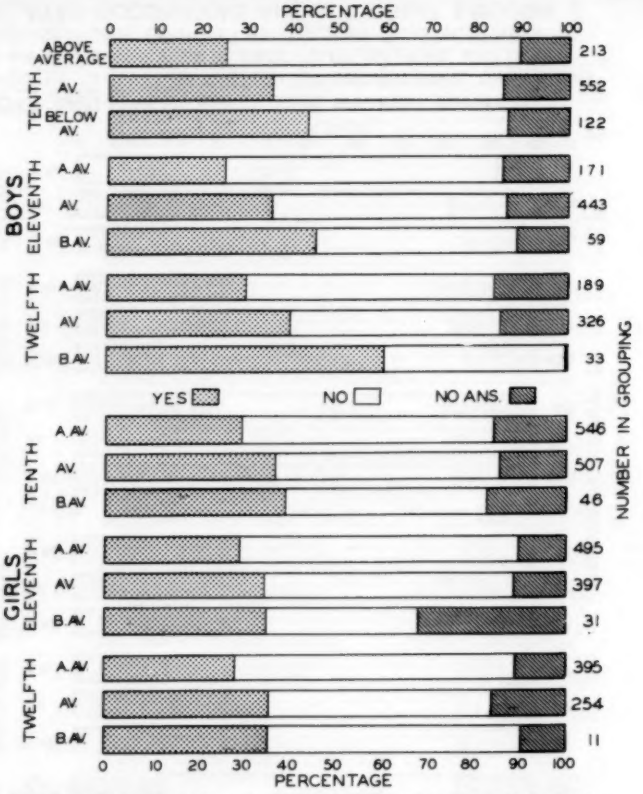
GRADES	NAME OF SCHOOL	A.D.A.
9-12	RAMONA H.S.	203
9-12	FALLBROOK U.H.S.	380
9-12	CORONADO H.S.	438
10-12	MAR VISTA S.H.S.	438
9-12	VISTA H.S.	567
10-12	SAN DIEGUITO H.S.	653
9-12	OCEANSIDE-CARLSBAD U.H.S.	908
10-12	SWEETWATER H.S.	909
9-12	ESCONDIDO U.H.S.	1080
10-12	CHULA VISTA S.H.S.	1345
9-12	EL CAJON VALLEY H.S.	1497
9-12	HELIX H.S.	1927
9-12	GROSSMONT H.S.	1952

FIG. 2



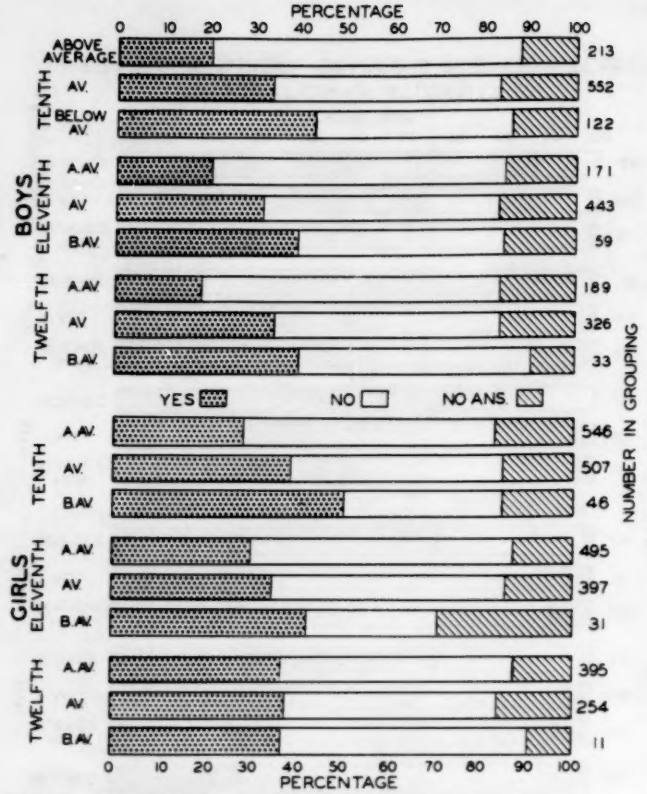
DISTRIBUTION OF STUDENTS BY AVERAGES OF SCHOOL GRADES & SCIENCE INTEREST

FIG. 3



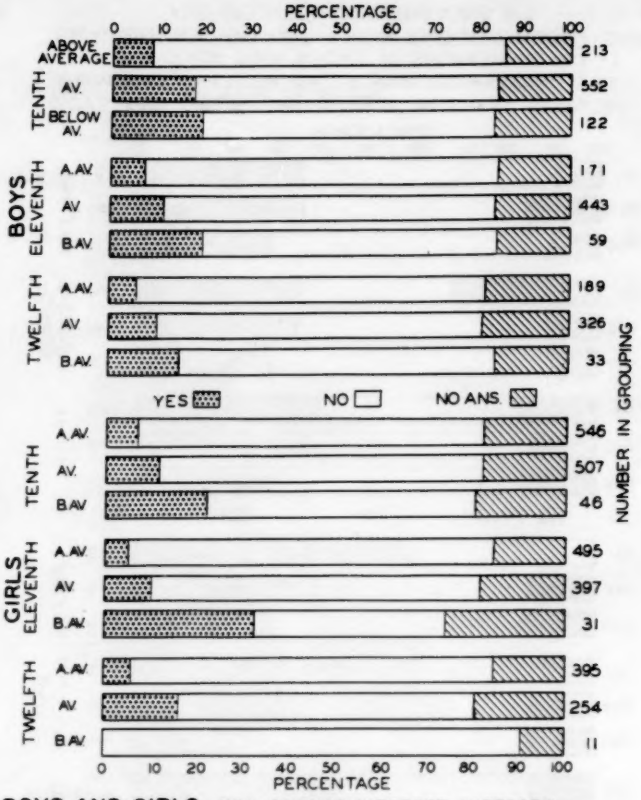
BOYS AND GIRLS, NON-SCIENCE INTEREST CATEGORY. ANSWERS TO QUESTION 10A, "IF YOUR OCCUPATIONAL CHOICE WAS IN A FIELD OTHER THAN SCIENCE OR ENGINEERING, WAS IT BECAUSE--- YOU DO NOT KNOW ENOUGH ABOUT SCIENCE AND RELATED OCCUPATIONS ?"

FIG. 4



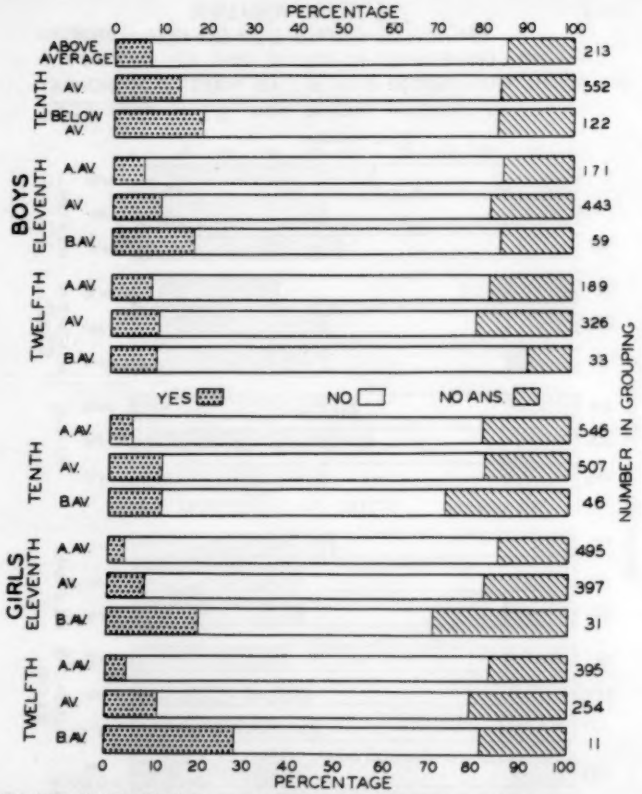
BOYS AND GIRLS, NON-SCIENCE INTEREST CATEGORY.
ANSWERS TO QUESTION 10 B, "IF YOUR OCCUPATIONAL CHOICE WAS IN A FIELD OTHER THAN SCIENCE OR ENGINEERING, WAS IT BECAUSE--- THEY ARE TOO DIFFICULT ?"

FIG. 5



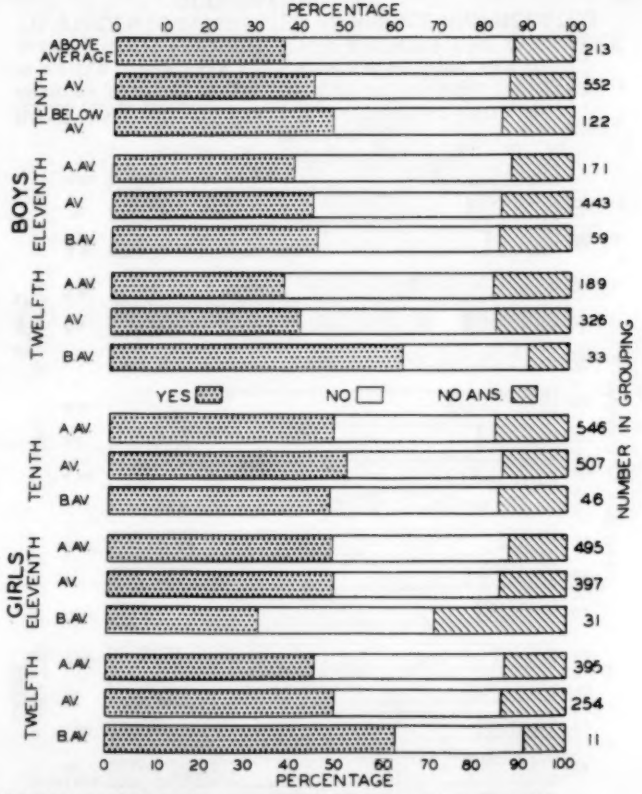
BOYS AND GIRLS, NON-SCIENCE INTEREST CATEGORY.
ANSWERS TO QUESTION 10 C, "IF YOUR OCCUPATIONAL CHOICE WAS IN A FIELD OTHER THAN SCIENCE OR ENGINEERING, WAS IT BECAUSE--- JOB OPPORTUNITIES IN SCIENCE AND RELATED OCCUPATIONS ARE NOT GREAT ENOUGH ?"

FIG. 6



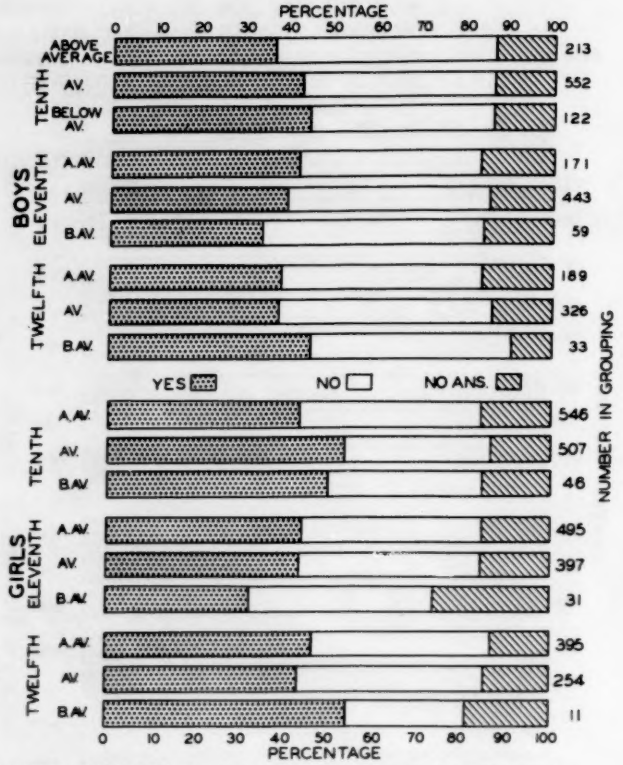
BOYS AND GIRLS, NON-SCIENCE INTEREST CATEGORY.
ANSWERS TO QUESTION 10 D, "IF YOUR OCCUPATIONAL CHOICE WAS IN A FIELD OTHER THAN SCIENCE OR ENGINEERING, WAS IT BECAUSE--- THEY DO NOT PAY ENOUGH ?"

FIG. 7



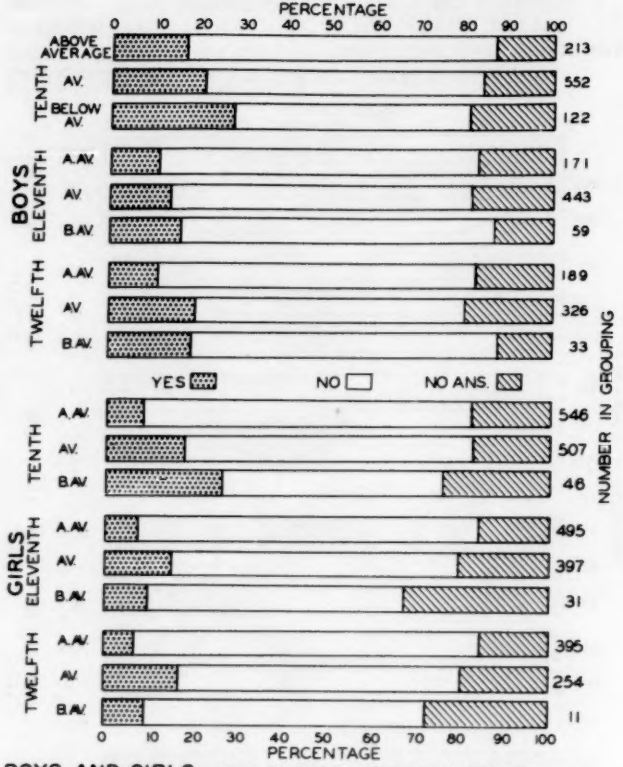
BOYS AND GIRLS, NON-SCIENCE INTEREST CATEGORY.
ANSWERS TO QUESTION 10 E, "IF YOUR OCCUPATIONAL CHOICE WAS IN A FIELD OTHER THAN SCIENCE OR ENGINEERING, WAS IT BECAUSE---YOU DO NOT ENJOY STUDYING SCIENCE ?"

FIG. 8



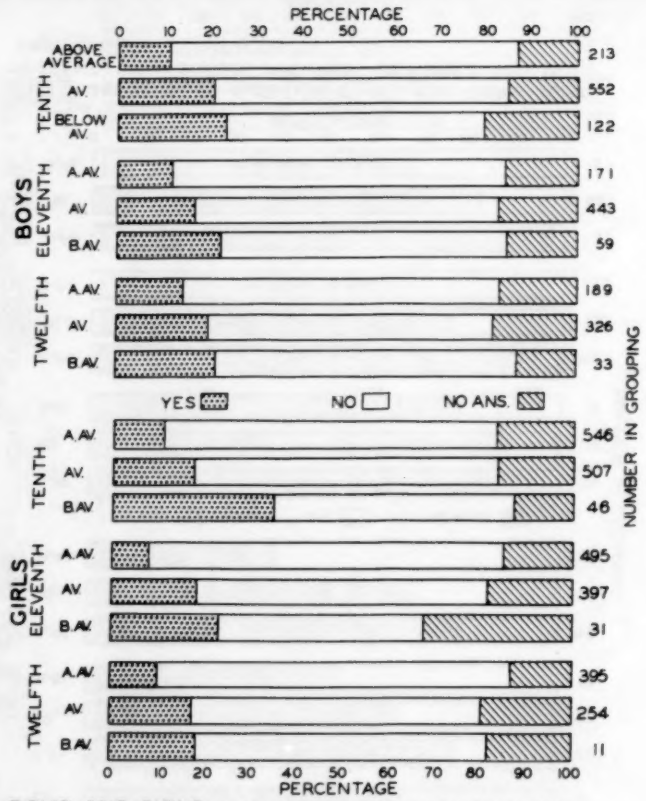
BOYS AND GIRLS, NON-SCIENCE INTEREST CATEGORY. ANSWERS TO QUESTION 10F, "IF YOUR OCCUPATIONAL CHOICE WAS IN A FIELD OTHER THAN SCIENCE OR ENGINEERING, WAS IT BECAUSE---YOU DO NOT ENJOY STUDYING MATHEMATICS ?"

FIG. 9



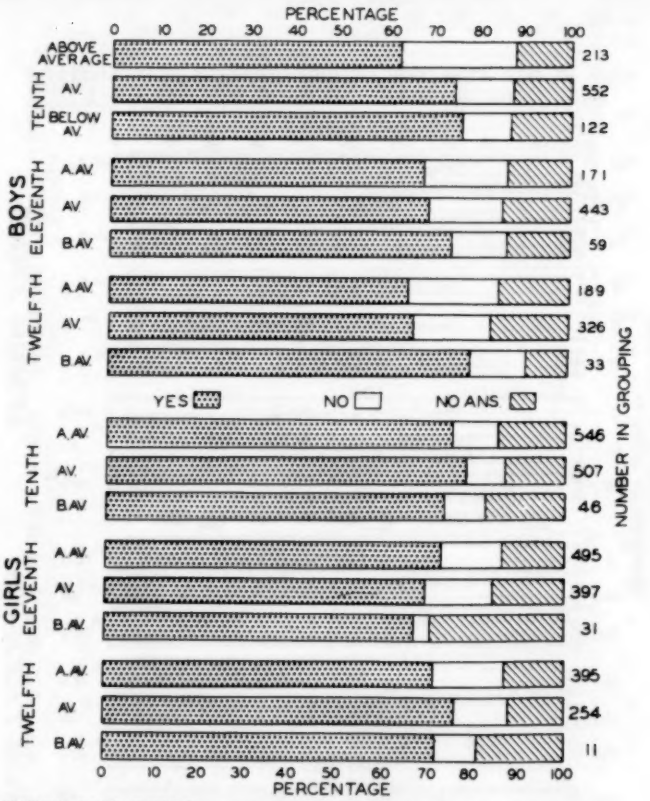
BOYS AND GIRLS, NON-SCIENCE INTEREST CATEGORY. ANSWERS TO QUESTION 10G, "IF YOUR OCCUPATIONAL CHOICE WAS IN A FIELD OTHER THAN SCIENCE OR ENGINEERING, WAS IT BECAUSE---NOT ENOUGH SCHOLARSHIPS ARE AVAILABLE TO STUDENTS INTERESTED IN SCIENCE AND RELATED OCCUPATIONS ?"

FIG. 10



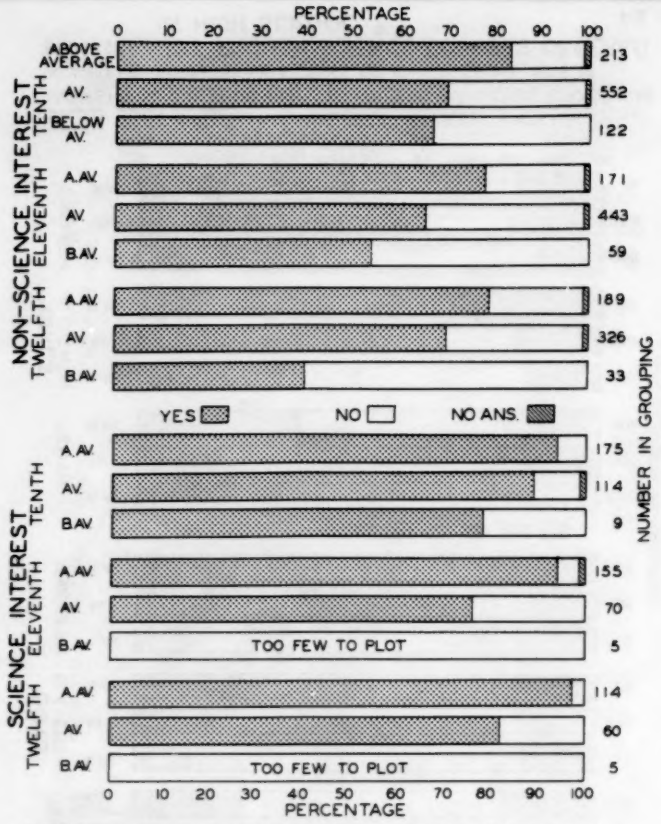
BOYS AND GIRLS, NON-SCIENCE INTEREST CATEGORY.
ANSWERS TO QUESTION 10 H, "IF YOUR OCCUPATIONAL CHOICE WAS IN A FIELD OTHER THAN SCIENCE OR ENGINEERING, WAS IT BECAUSE---NOT ENOUGH SCIENCE COURSES OFFERED IN HIGH SCHOOL ?"

FIG. 11



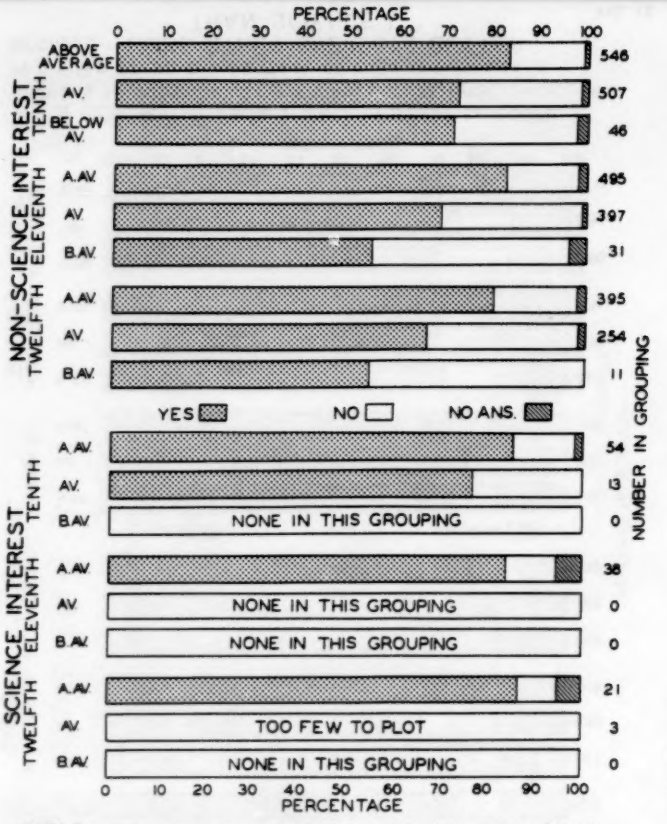
BOYS AND GIRLS, NON-SCIENCE INTEREST CATEGORY.
ANSWERS TO QUESTION 10 I, "IF YOUR OCCUPATIONAL CHOICE WAS IN A FIELD OTHER THAN SCIENCE OR ENGINEERING, WAS IT BECAUSE---I LIKE OTHER SUBJECTS BETTER THAN SCIENCE !"

FIG. 12



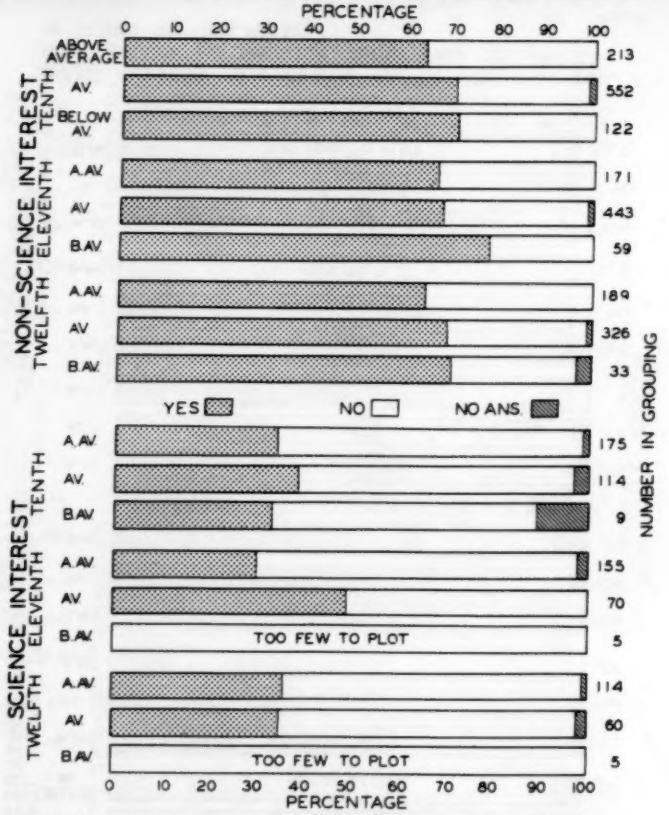
BOYS ANSWERS TO QUESTION 2: DO YOU THINK YOUR PRESENT HIGH SCHOOL PROGRAM WILL HELP YOU IN YOUR CHOSEN OCCUPATION?

FIG. 13



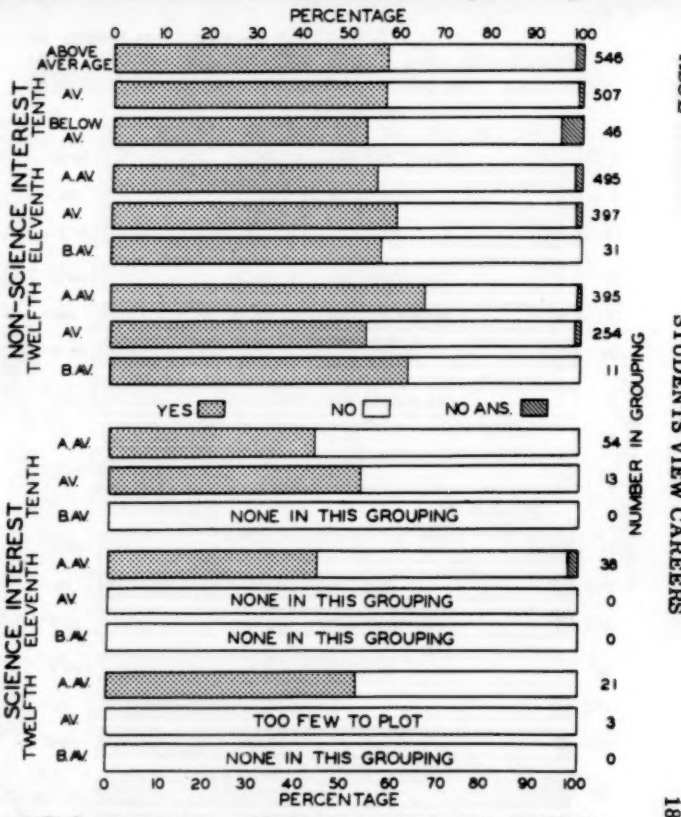
GIRLS ANSWERS TO QUESTION 2: DO YOU THINK YOUR PRESENT HIGH SCHOOL PROGRAM WILL HELP YOU IN YOUR CHOSEN OCCUPATION?

FIG. 14



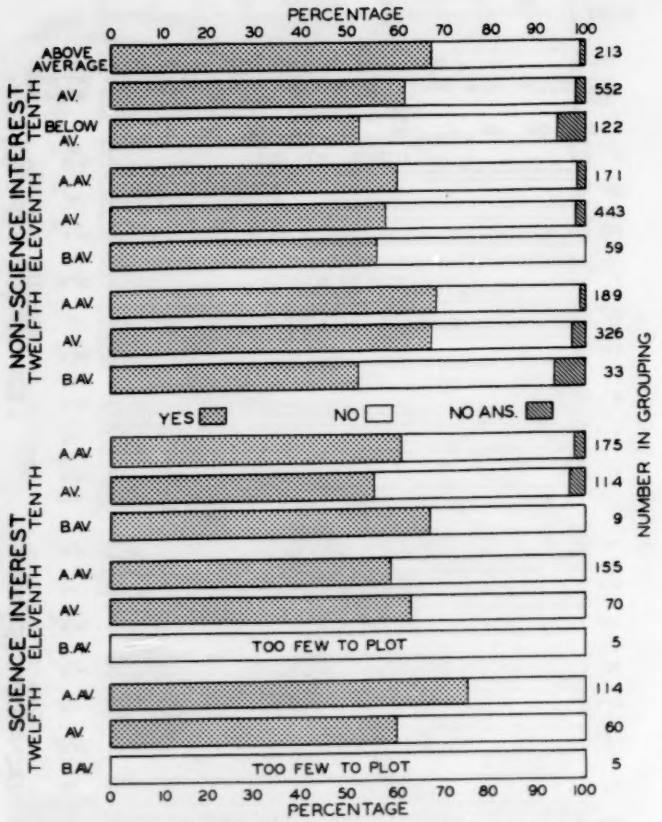
BOYS ANSWERS TO QUESTION 3: HAVE YOU WATCHED OR WORKED WITH SOMEONE IN THIS JOB ?

FIG. 15



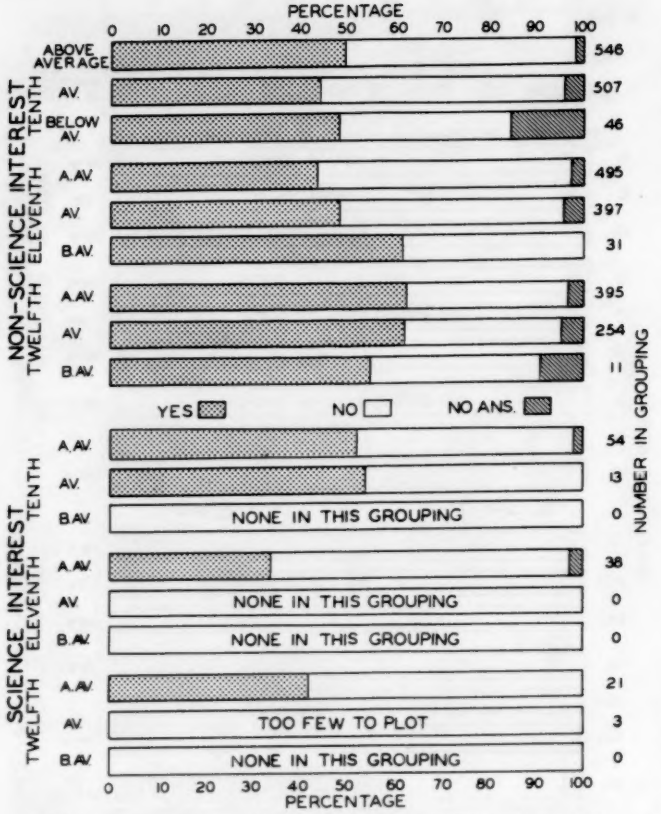
GIRLS ANSWERS TO QUESTION 3: HAVE YOU WATCHED OR WORKED WITH SOMEONE IN THIS JOB ?

FIG. 16



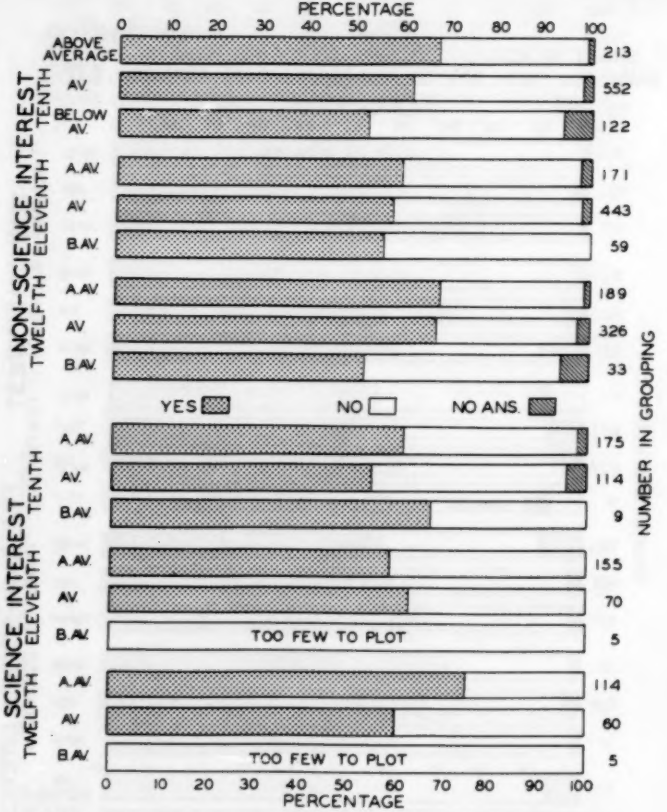
BOYS ANSWERS TO QUESTION 4A: DO YOU FEEL YOU HAVE ENOUGH INFORMATION ABOUT THIS OCCUPATION IN TERMS OF—SALARY—?

FIG. 17



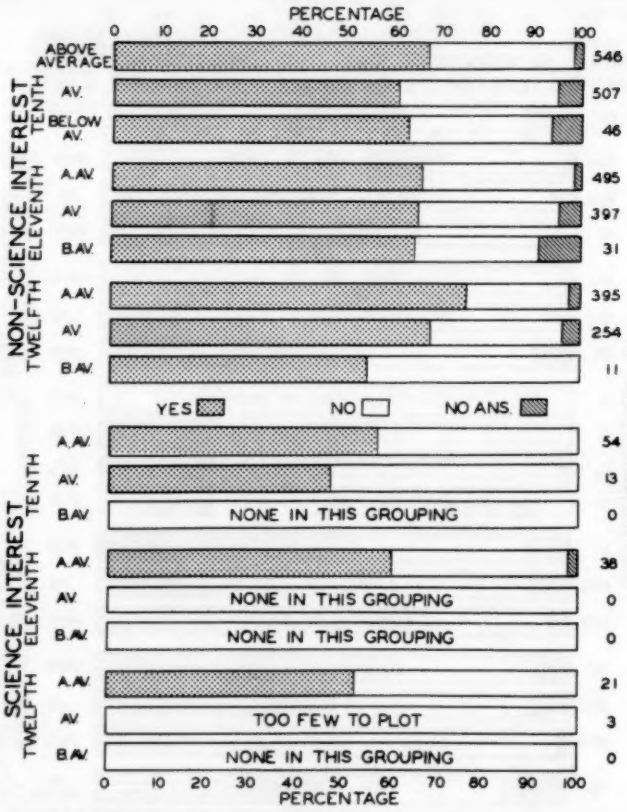
GIRLS ANSWERS TO QUESTION 4A: DO YOU FEEL YOU HAVE ENOUGH INFORMATION ABOUT THIS OCCUPATION IN TERMS OF—SALARY—?

FIG. 18



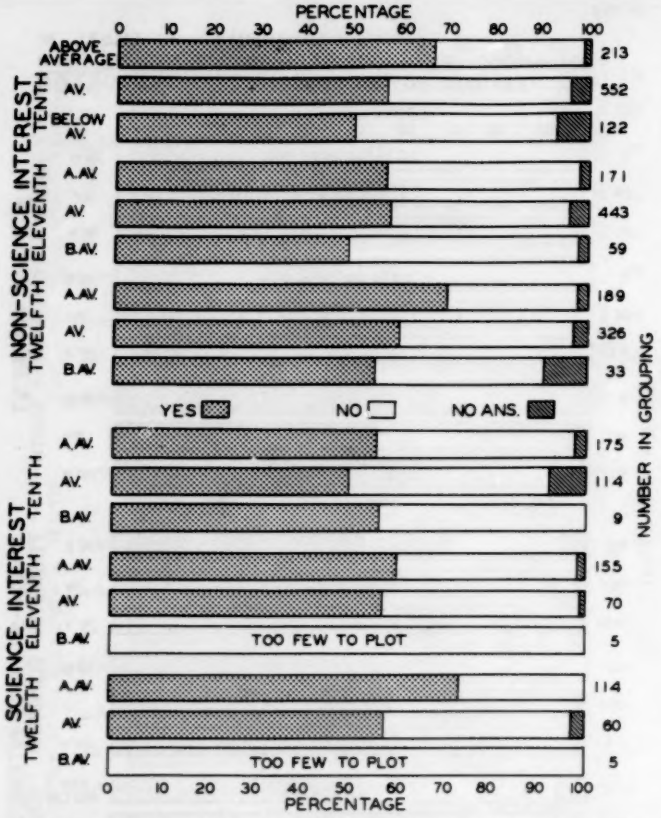
BOYS ANSWERS TO QUESTION 4B: DO YOU FEEL YOU HAVE ENOUGH INFORMATION ABOUT THIS OCCUPATION IN TERMS OF —TRAINING—?

FIG. 19



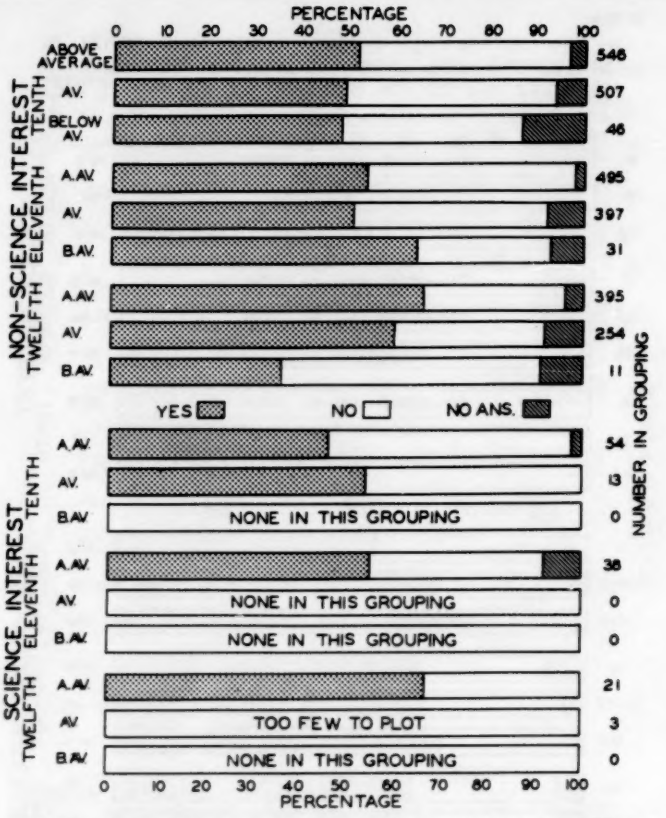
GIRLS ANSWERS TO QUESTION 4B: DO YOU FEEL YOU HAVE ENOUGH INFORMATION ABOUT THIS OCCUPATION IN TERMS OF —TRAINING—?

FIG. 20



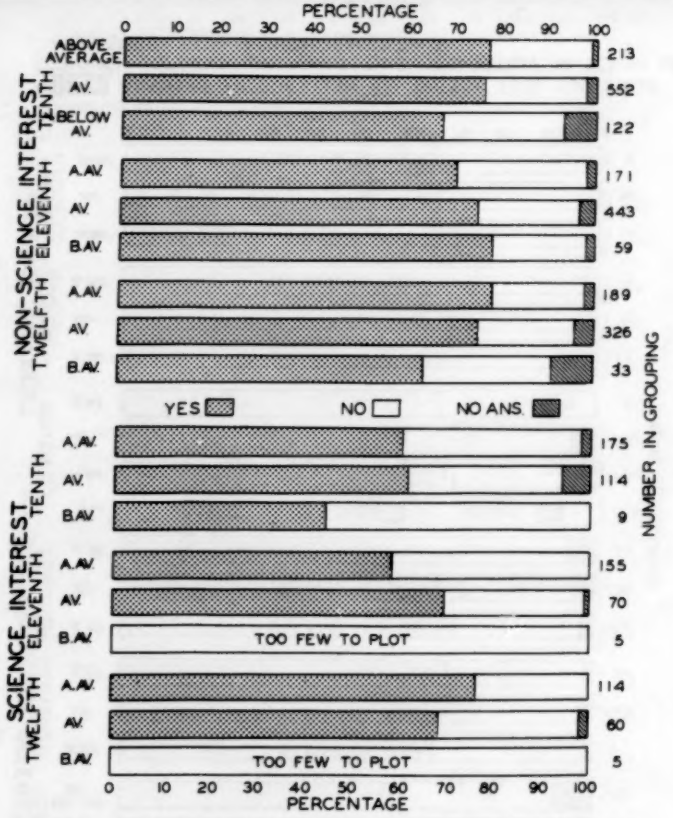
BOYS ANSWERS TO QUESTION 4C: DO YOU FEEL YOU HAVE ENOUGH INFORMATION ABOUT THIS OCCUPATION IN TERMS OF—SECURITY—?

FIG. 21



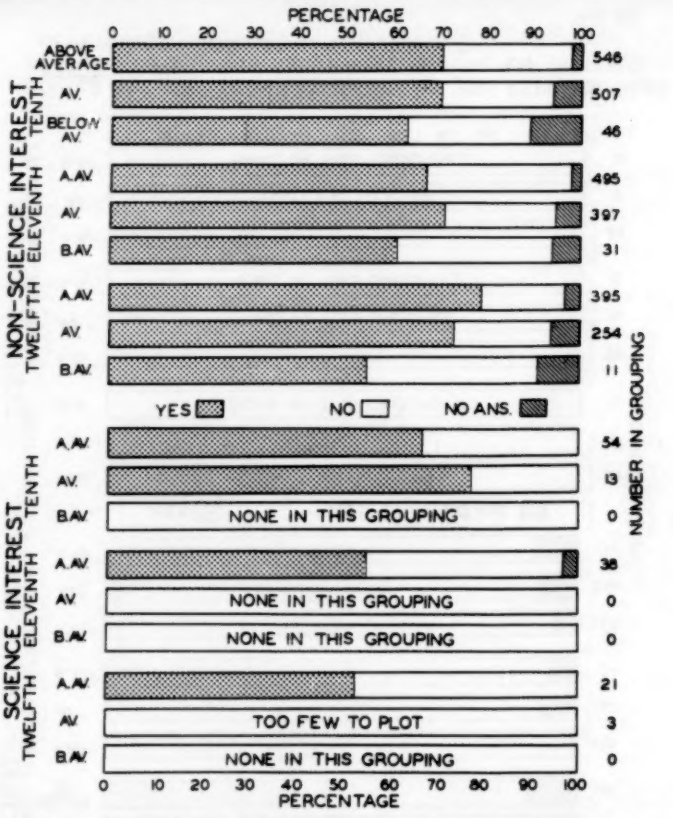
GIRLS ANSWERS TO QUESTION 4C: DO YOU FEEL YOU HAVE ENOUGH INFORMATION ABOUT THIS OCCUPATION IN TERMS OF—SECURITY—?

FIG. 22



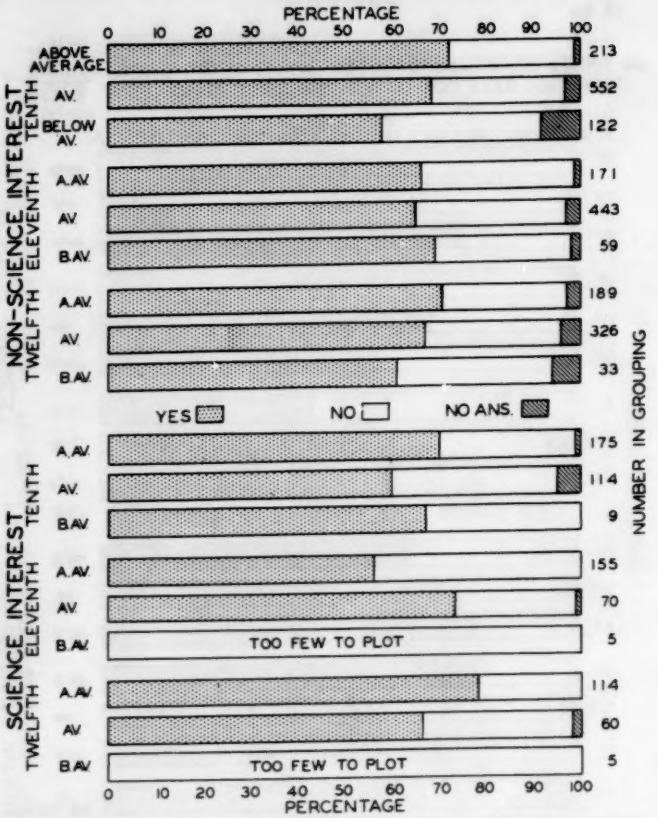
BOYS ANSWERS TO QUESTION 4D: DO YOU FEEL YOU HAVE ENOUGH INFORMATION ABOUT THIS OCCUPATION IN TERMS OF —WORKING CONDITIONS?

FIG. 23



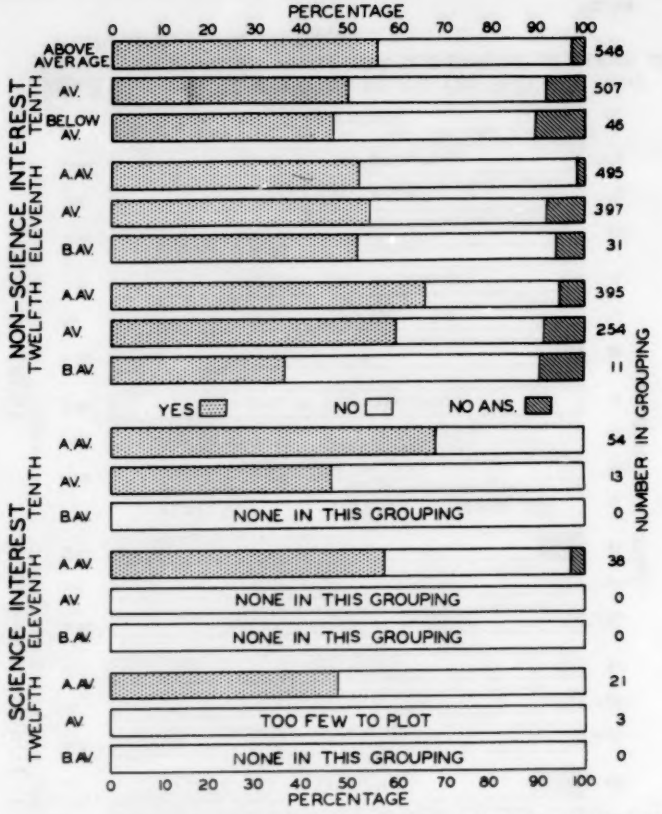
GIRLS ANSWERS TO QUESTION 4D: DO YOU FEEL YOU HAVE ENOUGH INFORMATION ABOUT THIS OCCUPATION IN TERMS OF —WORKING CONDITIONS—?

FIG. 24



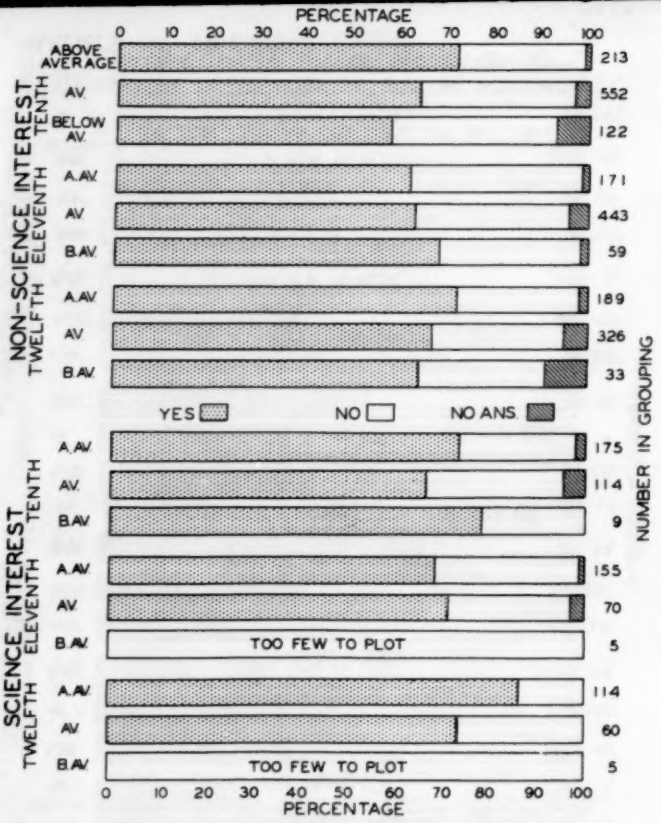
BOYS ANSWERS TO QUESTION 4E: DO YOU FEEL YOU HAVE ENOUGH INFORMATION ABOUT THIS OCCUPATION IN TERMS OF —CHANCE FOR ADVANCEMENT—?

FIG. 25



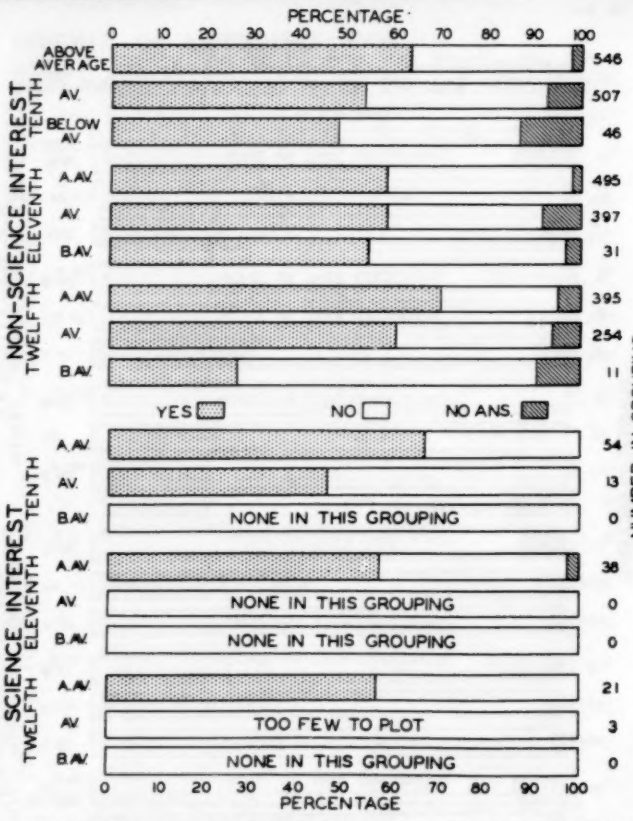
GIRLS ANSWERS TO QUESTION 4E: DO YOU FEEL YOU HAVE ENOUGH INFORMATION ABOUT THIS OCCUPATION IN TERMS OF—CHANCE FOR ADVANCEMENT—?

FIG. 26



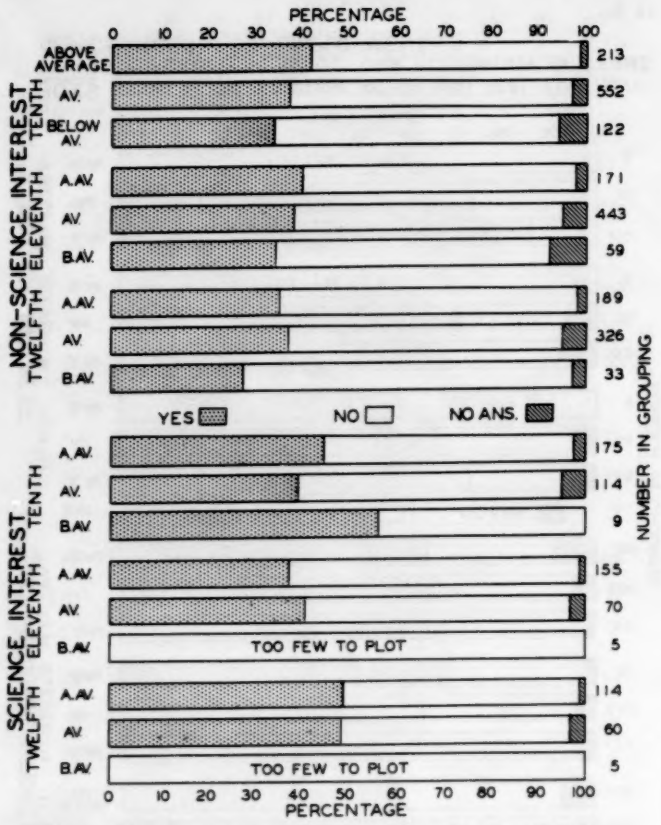
BOYS ANSWERS TO QUESTION 4F: DO YOU FEEL YOU HAVE ENOUGH INFORMATION ABOUT THIS OCCUPATION IN TERMS OF—CHANCES FOR EMPLOYMENT—?

FIG. 27



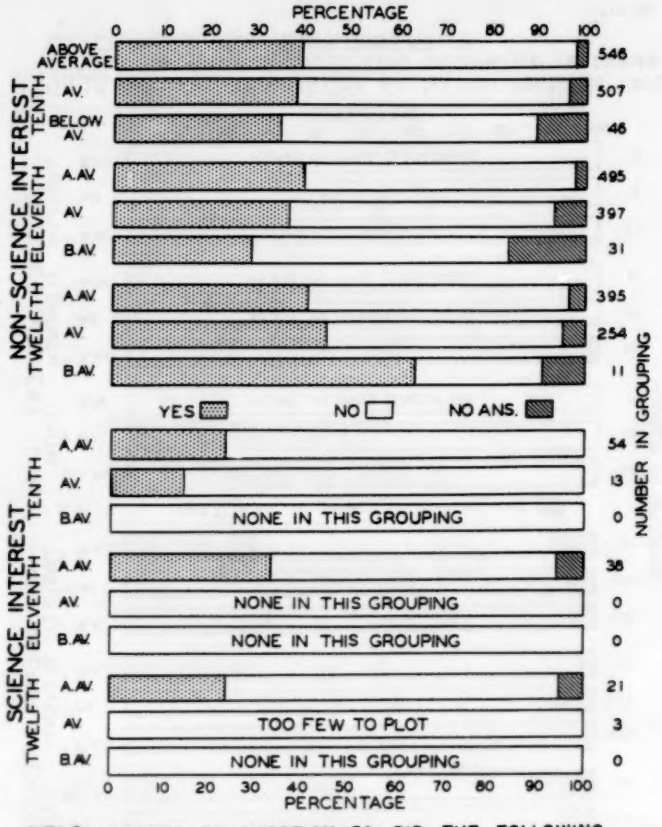
GIRLS ANSWERS TO QUESTION 4F: DO YOU FEEL YOU HAVE ENOUGH INFORMATION ABOUT THIS OCCUPATION IN TERMS OF—CHANCES FOR EMPLOYMENT—?

FIG. 28



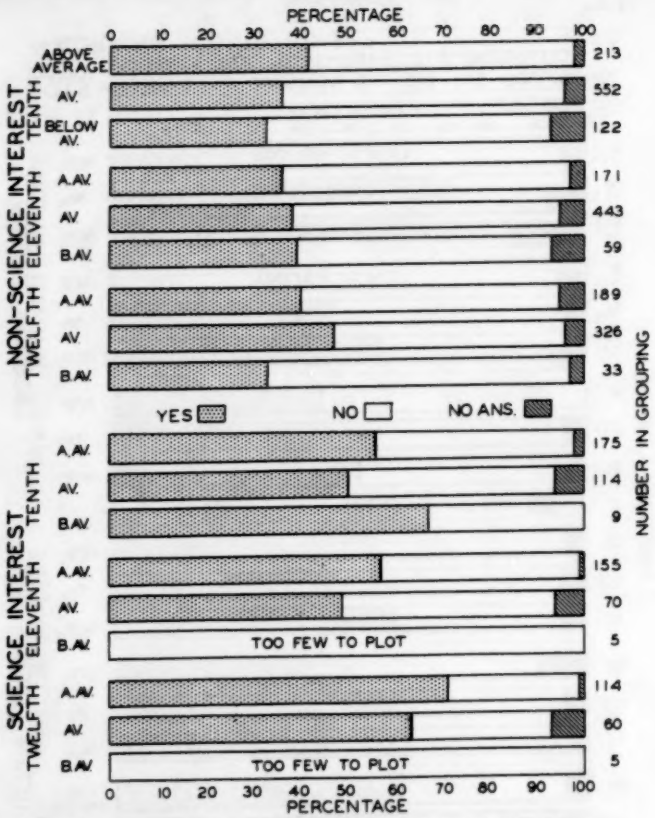
BOYS ANSWERS TO QUESTION 5A: DID THE FOLLOWING ITEMS INFLUENCE YOU TO CHOOSE THE OCCUPATION— PARENTS OR FRIENDS—?

FIG. 29



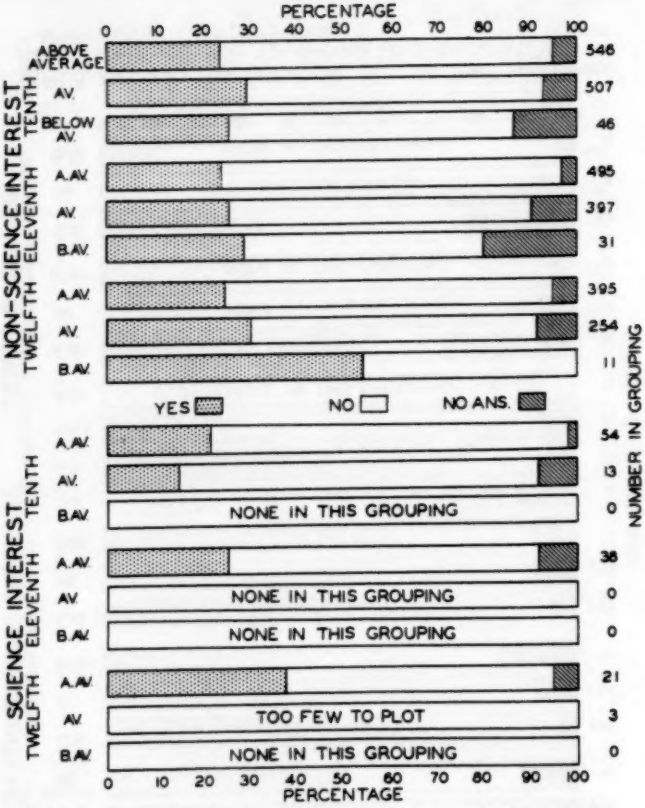
GIRLS ANSWERS TO QUESTION 5A: DID THE FOLLOWING ITEMS INFLUENCE YOU TO CHOOSE THE OCCUPATION— PARENTS OR FRIENDS—?

FIG. 30



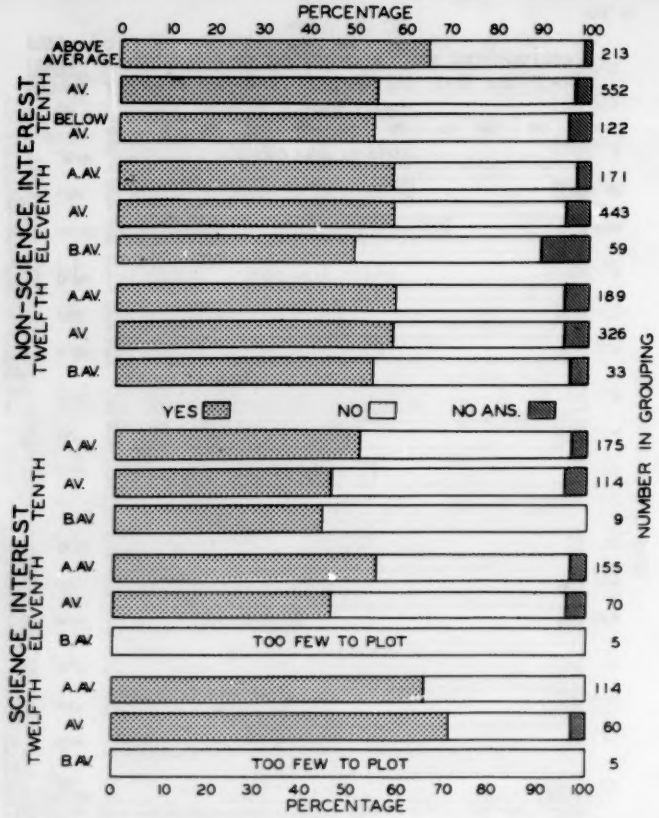
BOYS ANSWERS TO QUESTION 5B: DID THE FOLLOWING ITEM INFLUENCE YOU TO CHOOSE THE OCCUPATION— PAY–?

FIG. 31



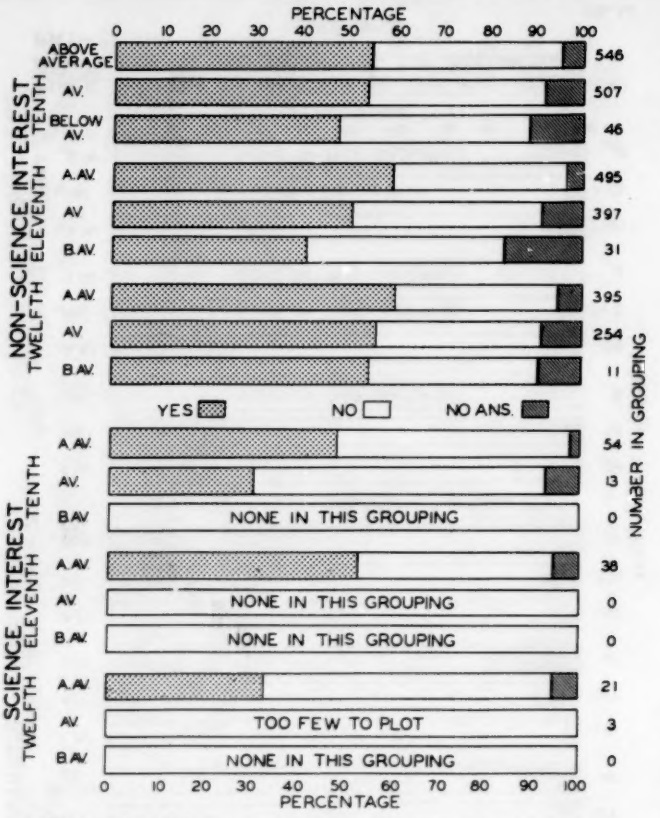
GIRLS ANSWERS TO QUESTION 5B: DID THE FOLLOWING ITEM INFLUENCE YOU TO CHOOSE THE OCCUPATION— PAY–?

FIG. 32



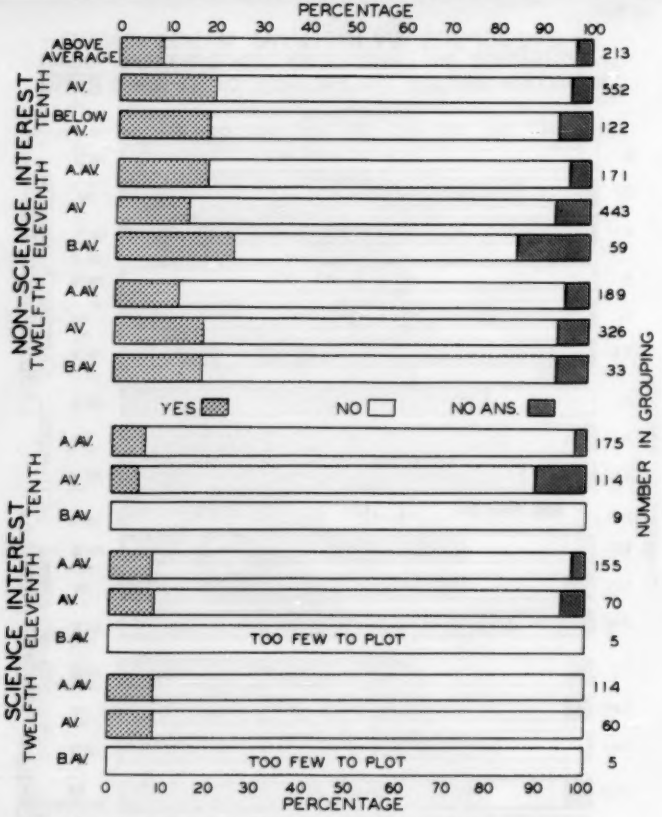
BOYS ANSWERS TO QUESTION 5C: DID THE FOLLOWING ITEMS INFLUENCE YOU TO CHOOSE THE OCCUPATION —WORKING CONDITIONS—?

FIG. 33



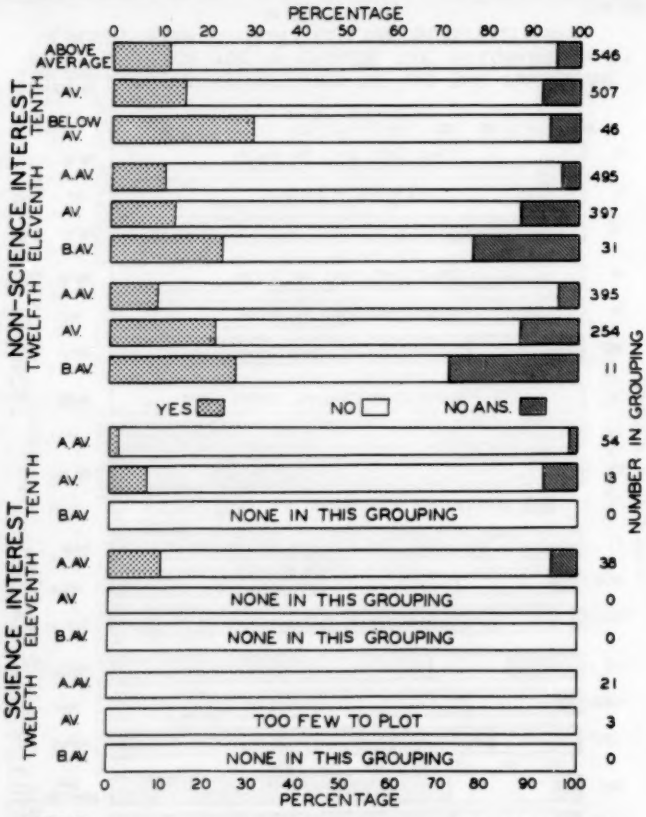
GIRLS ANSWERS TO QUESTION 5C: DID THE FOLLOWING ITEMS INFLUENCE YOU TO CHOOSE THE OCCUPATION —WORKING CONDITIONS—?

FIG. 34



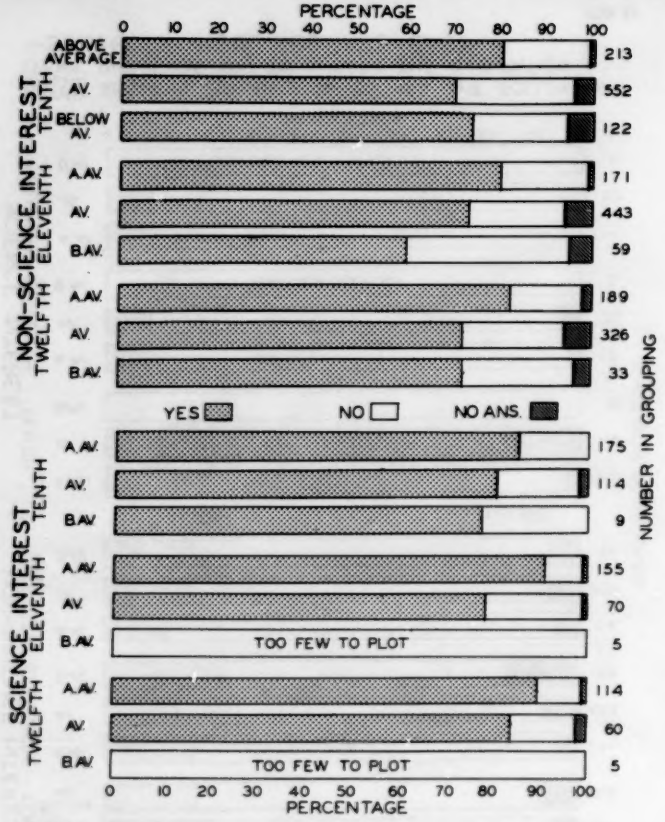
BOYS ANSWERS TO QUESTION 5D: DID THE FOLLOWING ITEMS INFLUENCE YOU TO CHOOSE THE OCCUPATION —SUBJECTS REQUIRED ARE EASY—?

FIG. 35



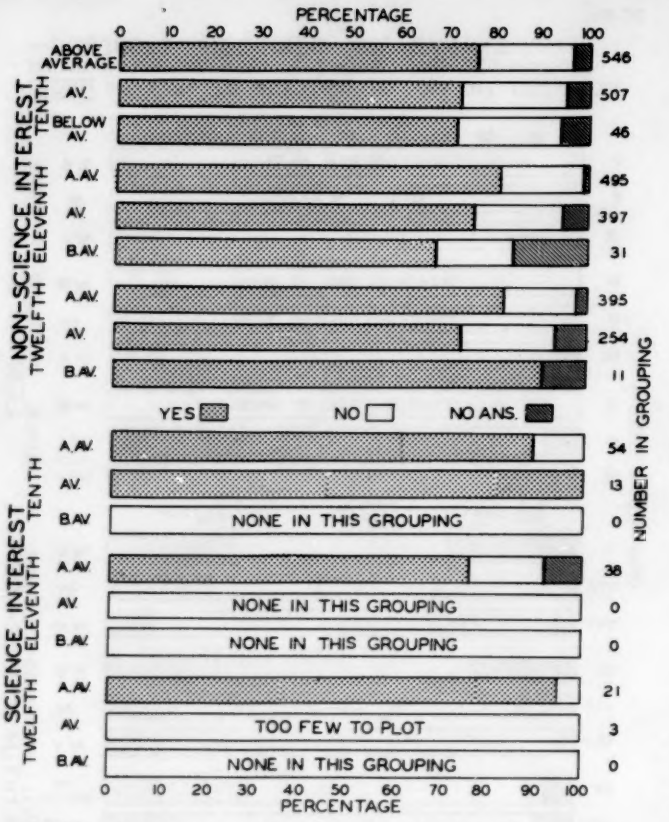
GIRLS ANSWERS TO QUESTION 5D: DID THE FOLLOWING ITEMS INFLUENCE YOU TO CHOOSE THE OCCUPATION —SUBJECTS REQUIRED ARE EASY—?

FIG. 36



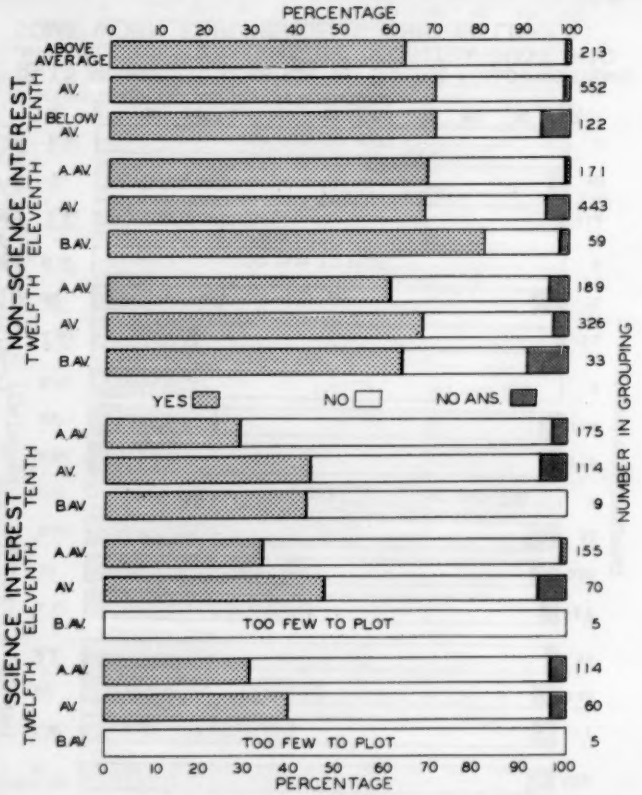
BOYS ANSWERS TO QUESTION 5E: DID THE FOLLOWING ITEMS INFLUENCE YOU TO CHOOSE THE OCCUPATION —LIKING FOR A PARTICULAR SUBJECT—?

FIG. 37



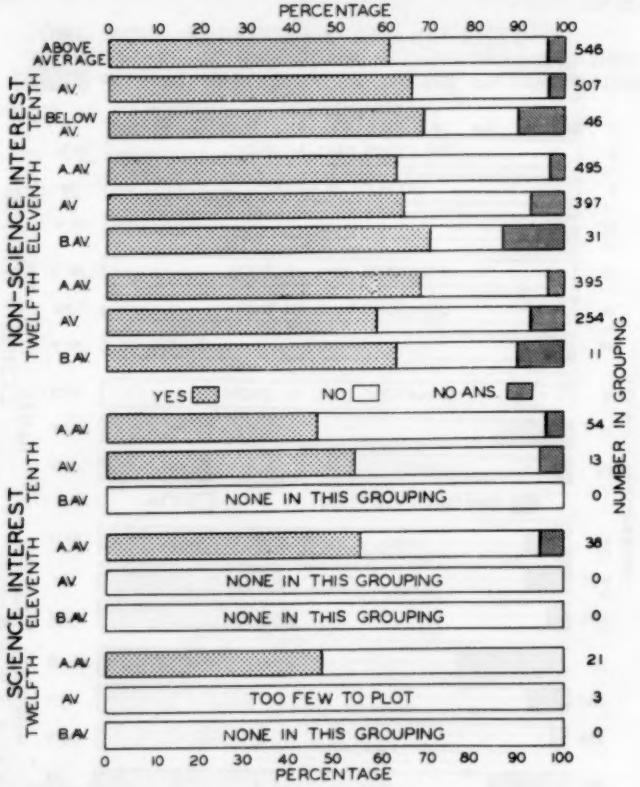
GIRLS ANSWERS TO QUESTION 5E: DID THE FOLLOWING ITEMS INFLUENCE YOU TO CHOOSE THE OCCUPATION —LIKING FOR A PARTICULAR SUBJECT—?

FIG. 38



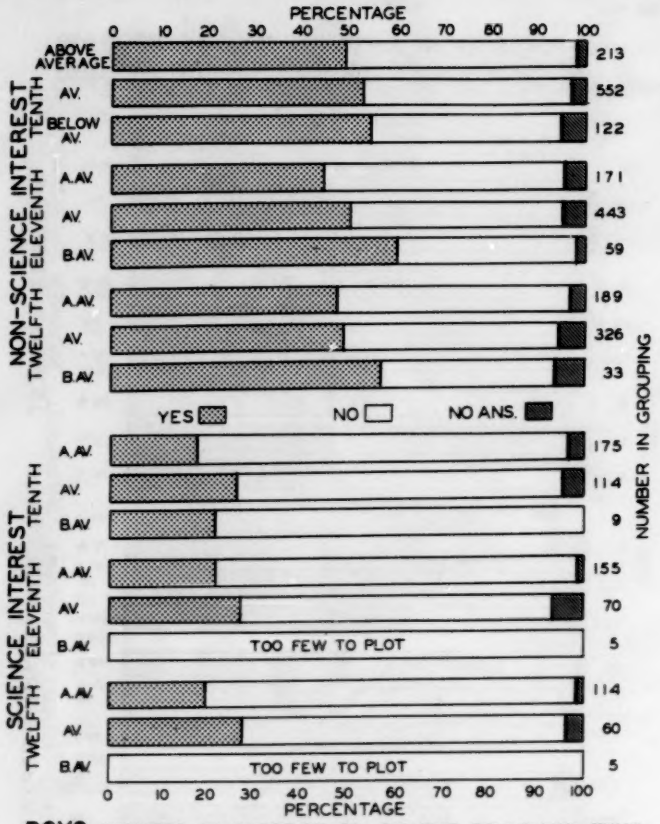
BOYS ANSWERS TO QUESTION 5F: DID THE FOLLOWING ITEMS INFLUENCE YOU TO CHOOSE THE OCCUPATION—HAVE WATCHED PEOPLE AT WORK IN THIS JOB—?

FIG. 39



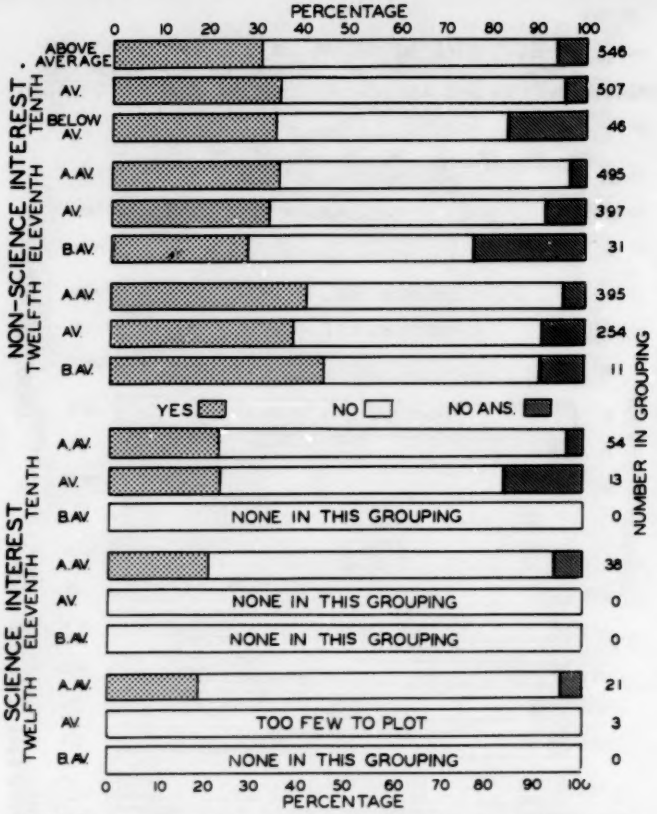
GIRLS ANSWERS TO QUESTION 5F: DID THE FOLLOWING ITEMS INFLUENCE YOU TO CHOOSE THE OCCUPATION—HAVE WATCHED PEOPLE AT WORK IN THIS JOB—?

FIG. 40



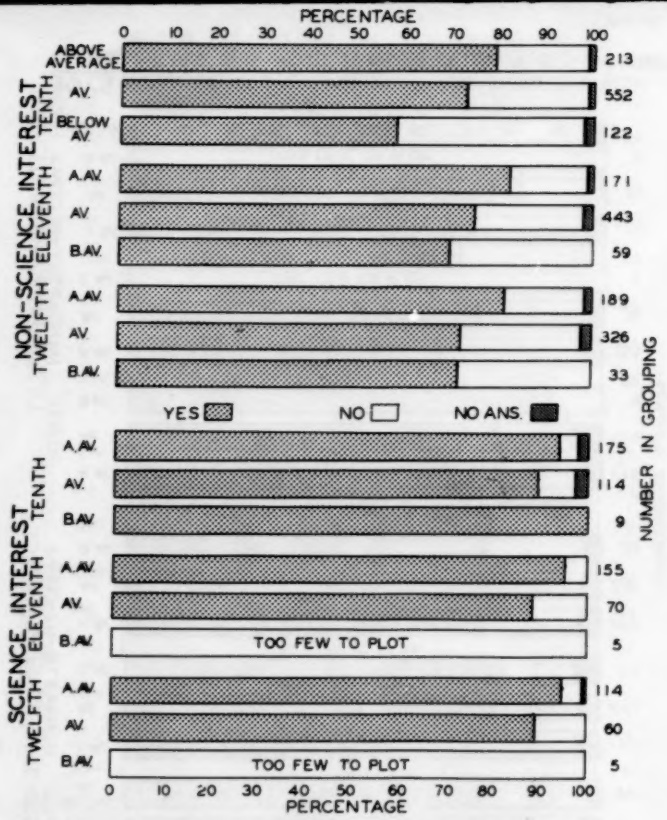
BOYS ANSWERS TO QUESTION 5G: DID THE FOLLOWING ITEMS INFLUENCE YOU TO CHOOSE THE OCCUPATION—HAVE HAD SOME WORK EXPERIENCE IN THIS FIELD—?

FIG. 41



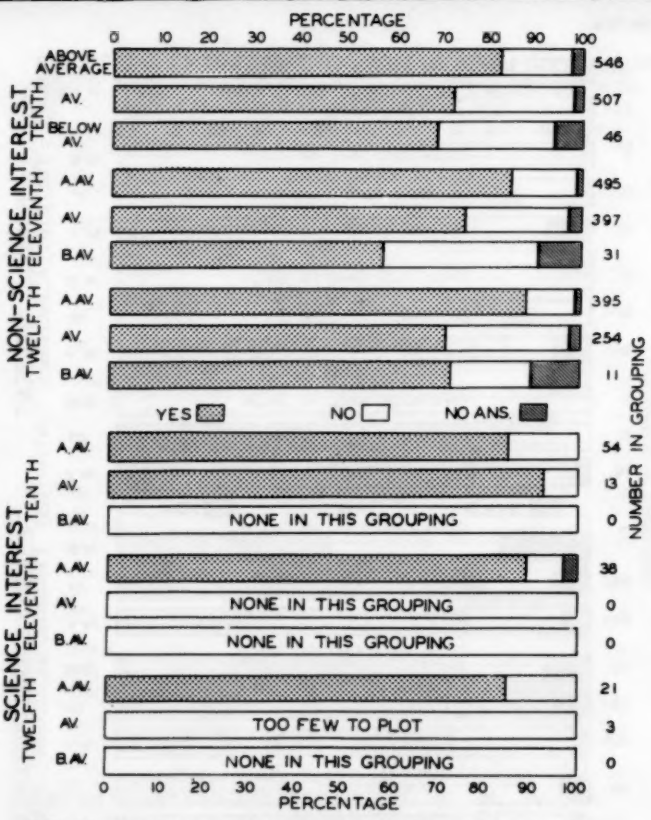
GIRLS ANSWERS TO QUESTION 5G: DID THE FOLLOWING ITEMS INFLUENCE YOU TO CHOOSE THE OCCUPATION—HAVE HAD SOME WORK EXPERIENCE IN THIS FIELD—?

FIG. 42



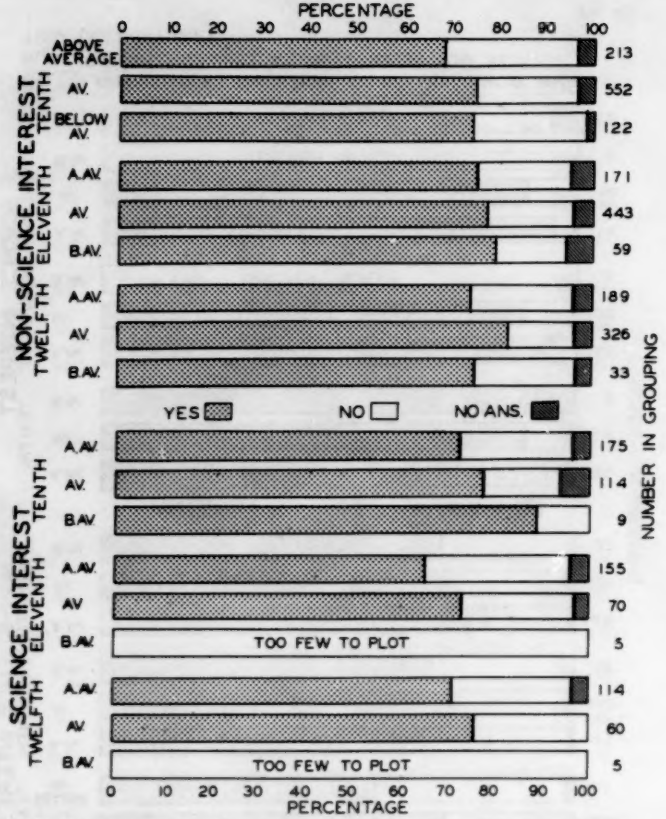
BOYS ANSWERS TO QUESTION 6: DO YOU KNOW WHAT SUBJECTS IN HIGH SCHOOL WILL HELP YOU IN THIS OCCUPATION?

FIG. 43



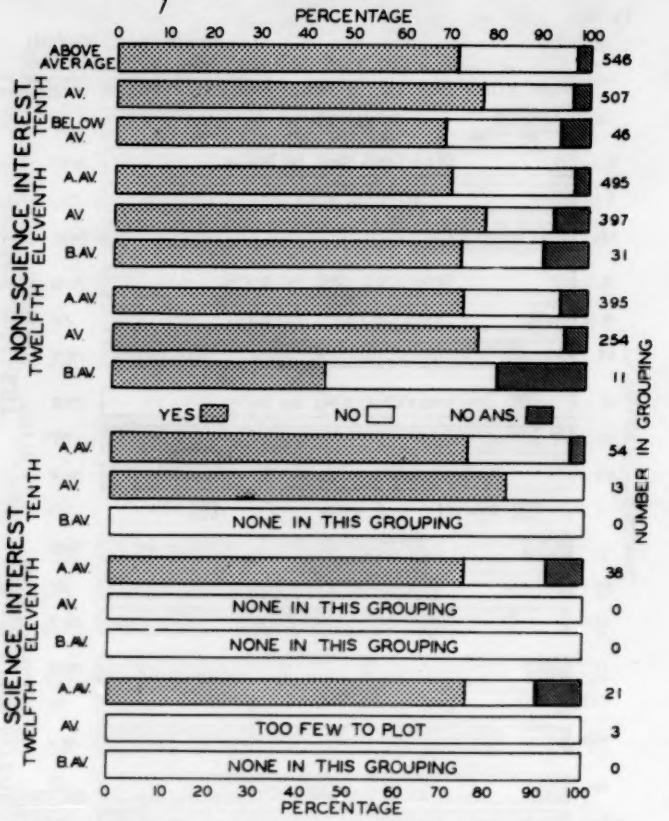
GIRLS ANSWERS TO QUESTION 6: DO YOU KNOW WHAT SUBJECTS IN HIGH SCHOOL WILL HELP YOU IN THIS OCCUPATION?

FIG. 44



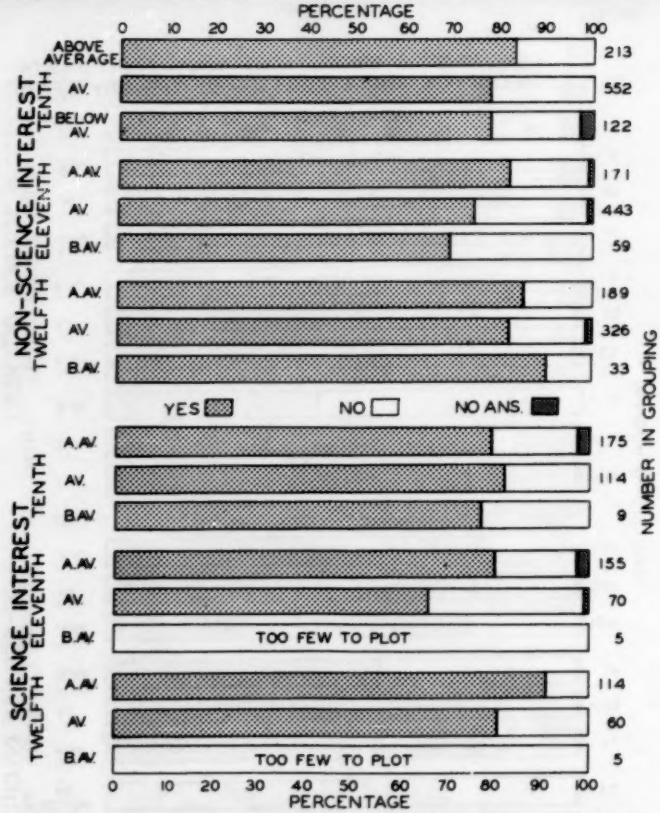
BOYS ANSWERS TO QUESTION 7: DO YOU THINK THE HIGH SCHOOL SHOULD GIVE MORE TRAINING IN OTHER OCCUPATIONS?

FIG. 45



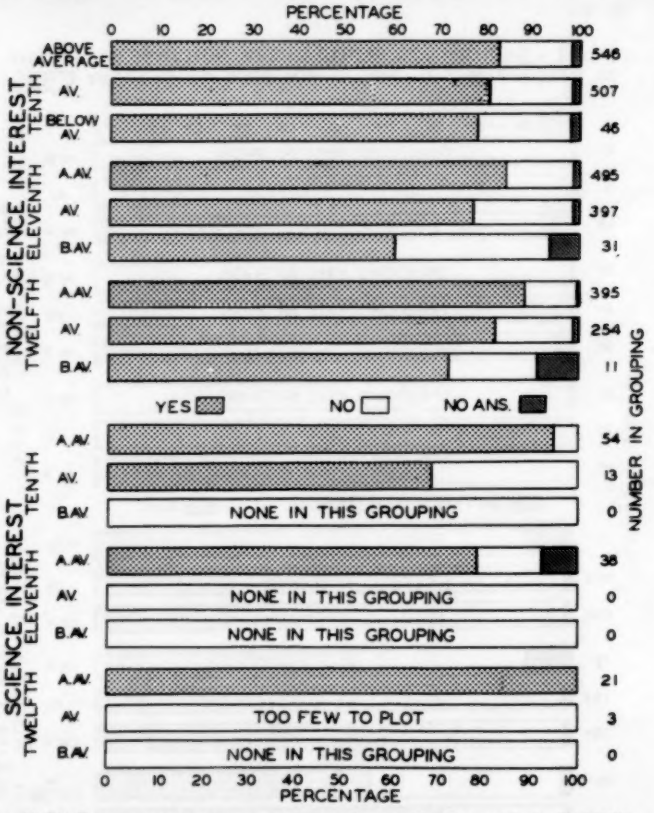
GIRLS ANSWERS TO QUESTION 7: DO YOU THINK THE HIGH SCHOOL SHOULD GIVE MORE TRAINING IN OTHER OCCUPATIONS?

FIG. 46



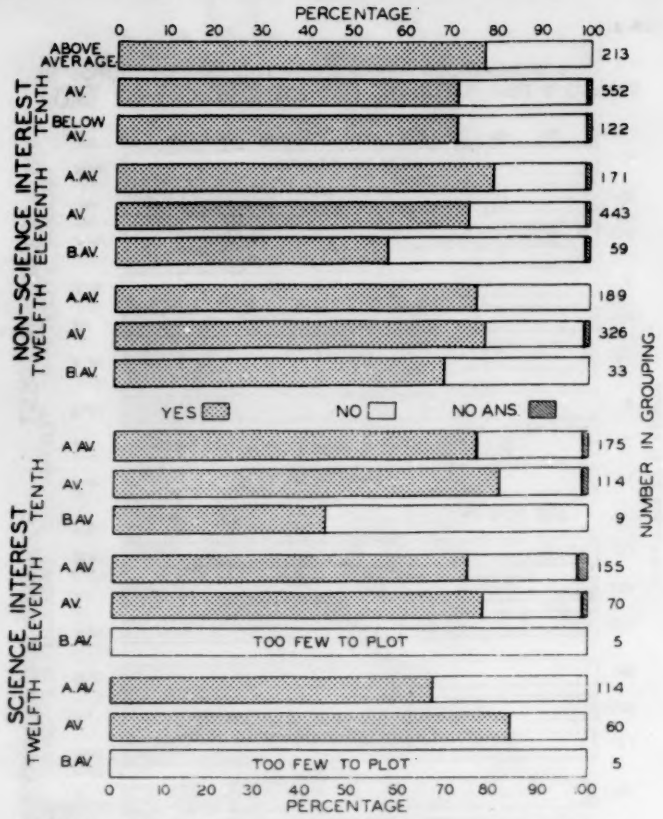
BOYS ANSWERS TO QUESTION 8: HAVE YOU HAD A CHANCE IN SCHOOL TO FIND OUT ABOUT OTHER OCCUPATIONS?

FIG. 47



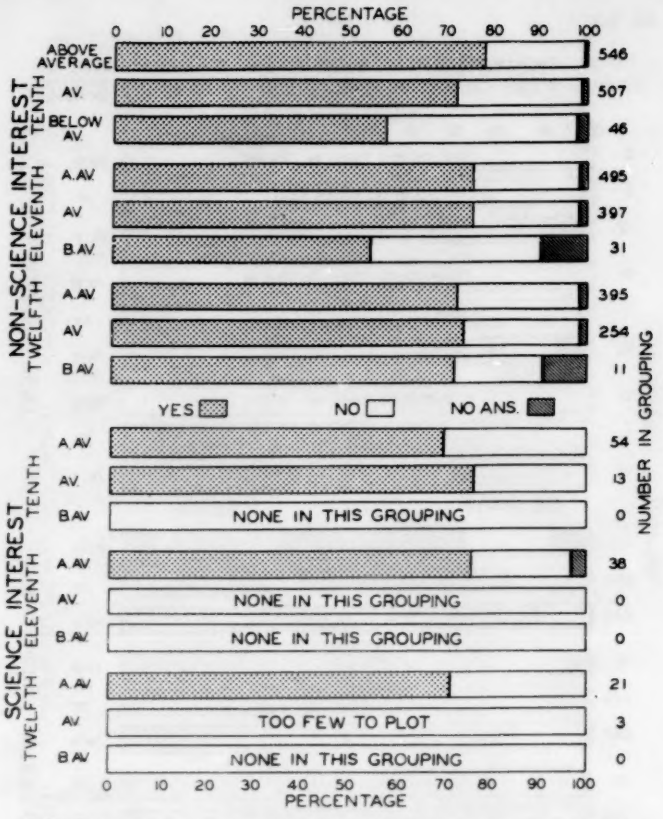
GIRLS ANSWERS TO QUESTION 8: HAVE YOU HAD A CHANCE IN SCHOOL TO FIND OUT ABOUT OTHER OCCUPATIONS?

FIG. 48



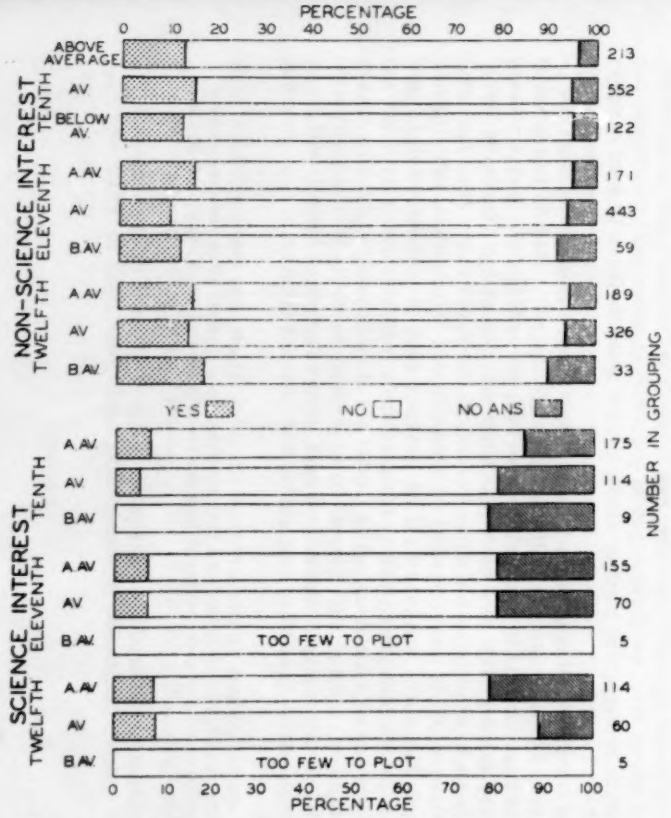
BOYS ANSWERS TO QUESTION 9: ARE YOU INTERESTED IN HAVING INFORMATION ABOUT OTHER OCCUPATIONS?

FIG. 49



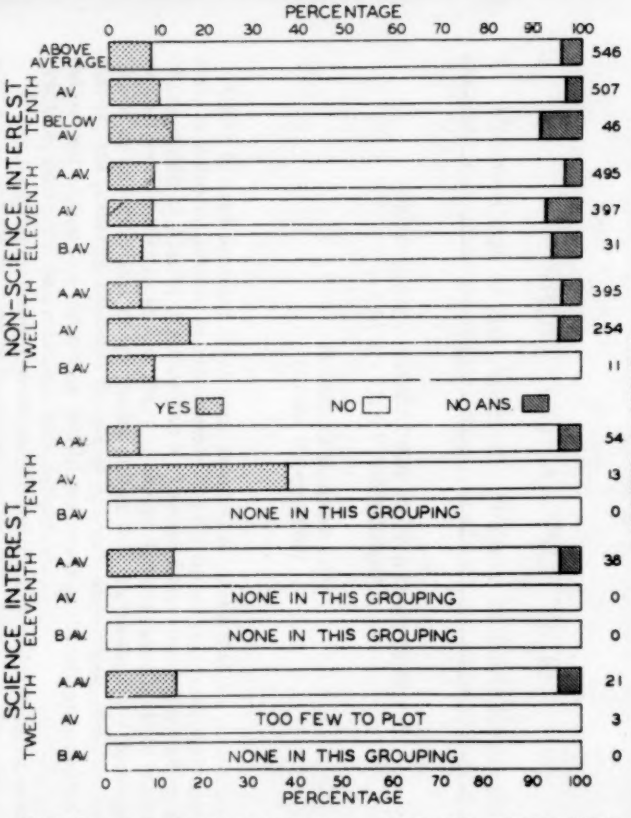
GIRLS ANSWERS TO QUESTION 9: ARE YOU INTERESTED IN HAVING INFORMATION ABOUT OTHER OCCUPATIONS?

FIG. 50



BOYS ANSWERS TO QUESTION II: HAVE YOU LISTED YOUR CHOSEN OCCUPATION ONLY BECAUSE YOU NEEDED ONE TO ANSWER THIS QUESTIONNAIRE?

FIG. 51



GIRLS ANSWERS TO QUESTION II: HAVE YOU LISTED YOUR CHOSEN OCCUPATION ONLY BECAUSE YOU NEEDED ONE TO ANSWER THIS QUESTIONNAIRE?

FIG. 52

Paper 1869 December, 1958 PP 1

Journal of

PROFESSIONAL PRACTICE

Proceedings of the American Society of Civil Engineers

ENGINEERING EDUCATION AS IT AFFECTS UNITY IN THE PROFESSION[a]

Frederick C. Lindvall[1]
(Proc. Paper 1869)

Unity to have meaning must have substance. More than an occasional rally to common action, an affirmation of faith as an engineer, a statement of principles of ethical practice and a loose confederation of our several professional societies is necessary to unity. Indeed these factors would follow as consequences of true unity rather than as means for achieving it. Rather, the powerful cohesive forces of common objectives, common education and mutual understanding should permeate all of our engineering practice, education and relations with the public.

These unifying influences must stem from a basic understanding of our profession and its service to mankind, the creative nature of its work, the interplay of basic science, analysis, and design, and the social and economic evaluation of new engineering systems and projects. Through identification and extension of the common substance of engineering we must create this common base of understanding without which no truly professional status can be achieved.

We must be engineers first, with a specialist designation second in our thinking and attitudes. Psychologically the title "Engineer" should have the greater appeal, rather than the narrower designation of "Electrical Engineer", "Civil Engineer" and so on. Our medical friends with their greater professional unity are, first of all, doctors of medicine regardless of specialization. The professional identification is, Robert Smith, M. D., - practice limited to Pediatrics, or John Roberts, M. D., Radiology. This radiologist has his specialized journals, a radiological society, and professional intercourse with other specialists in his field. At the same time he has his identification with all other medical practitioners. By analogy, an engineer might list himself as Robert Smith, Eng. Foundation Engineering, or John Roberts, Eng. Structural Design. But is this just quibbling, setting up a

Note: Discussion open until May 1, 1959. To extend the closing date one month, a written request must be filed with the Executive Secretary, ASCE. Paper 1869 is part of the copyrighted Journal of Professional Practice Division, Proceedings of the American Society of Civil Engineers, Vol. 84, No. PP 1, December, 1958.

a. Presented at the June, 1958 ASCE Convention in Portland, Oregon.

1. Chmn., Div. of Eng., Calif. Inst. of Technology, Pasadena, Calif.

distinction without a difference, playing with words? No, because the psychological implications are quite basic, particularly so for the student and the young engineer who seek the satisfaction of group identification. If this group represents solely a specialty rather than a unified engineering profession, the young mind will be channeled from the start and will tend to reject the broader and more powerful aspects of engineering. This broader approach also suggests an education which is more fundamental and more comprehensive than at present.

The basic concepts of unity and common subject matter must come early and continuously in the educational experience of the young engineer. Our academic curricula follow the pattern which was established many years ago, paralleling quite closely the professional engineering societies in name and objectives. Professional societies have splintered from a single split between military and civilian engineering to more and more detailed subdivision and classification of engineering. Similarly, college curricula have tended to proliferate, usually copying what appeared to be a trend in industry and after the fact rather than in anticipation of fields of specialization. Thus it is not uncommon at a large university to find at least a dozen colors and flavors of engineering education not including some of the inter-disciplinary curricula, such as Engineering Physics, Engineering Science, Applied Physics, Applied Mechanics, etc.

Despite the insistence of educators that all engineering has a strong common core of basic science and the engineering sciences, and that only minor differences give identity to the various curricula labels,—the student remains unconvinced of the unity of engineering. He cannot help but be impressed with the Industrial Engineering Professor professing to make Industrial Engineering seem different from Mechanical Engineering and the Structural Engineering Professor emphasizing heavy walled sections while the Aeronautical Structures Professor is directing the student's attention to thin walled structures. The Electrical Engineering Professor who is interested in Power, talks about transmission lines as though they were fundamentally different from the transmission lines which the Communications Professor describes. The differences extend also to the so-called service courses which one engineering department gives for students from other options. These service courses are frequently warped to conform to what the customer thinks are the needs of his students, rather than to leave to the judgment of the other Professor the subject matter which he deems right for the non-specialist in his field. The net result is that these service courses tend to be something which the students take under protest without ever appreciating the fact that much of the strange material may be familiar stuff, only in a strange language.

In the first two years of engineering education the students are largely in the hands of non-engineers who present the basic science—Physics, Mathematics, Chemistry,—English, History, etc., with no professional engineering concern. This is instruction for two years in subjects which for most students are merely the acquisition of skill, learning of principles, techniques and means to the end, that is, to the engineering courses which are to follow. The student gets no feeling of engineering unity or coherence, except the general feeling that all engineers need some Physics, all engineers use Mathematics to a greater or lesser extent, all engineers should be able to read and write. In some schools an attempt to alter this situation appears by having Freshman Engineering Orientation, Engineering Problems,

Elementary Engineering Analysis, or some such title in which members of the engineering faculty have an opportunity to present representative engineering problems to the students, problems which are sometimes of rather broad scope but for which the student is not expected to be ready to analyze details.

Then under our typical departmental academic organization the division of students into options occurs. In fact some schools in order to hasten specialized professional orientation, introduce departmental subjects in the sophomore year with the Electricals separate from the Mechanicals at that level, if not in the freshman year itself, for example. From then on, the student is completely channeled except for some common subjects which all engineers take, although not necessarily with the same scope and intensity. Applied Mechanics is one of these. Unfortunately, in the United States Applied Mechanics in Engineering Schools has meant essentially a course of rather limited scope, covering Statics, Dynamics and Strength of Materials. Only recently have some schools begun to use the broader concept of Applied Mechanics which has long been common in Europe in which such topics as Elasticity, Fluid Mechanics, Vibrations, etc. are all included. Here, important generalized concepts and common ideas are not lost as they tend to be in some of our neatly packaged courses.

Our historic curricular arrangements have merit, but they are not necessarily sacred. In the American Society for Engineering Education Report on Social-Humanistic Studies, a very penetrating remark is made: "Reorganizing an academic curriculum is like trying to move a graveyard." We have tradition, sentiment, even reverence for present values, real or presumed, in existing curriculum objectives and patterns. We have "vested interests" in certain courses, syllabi and textbooks, as well as the human reaction to receive a proposal for change as a personal criticism of present teaching. We also discover that some alumni become distrubed over changes in the educational pattern often through misunderstanding and misinformation. Likewise, the professional societies whose names are so closely identified with the labels of our standard engineering curricula, have profound and proper concern for education which is consistent with their professional objectives.

Professional men and educators are immersed in a rapidly changing technology. In the past ten years a whole series of new developments have stimulated profound changes in some engineering curricula. Radar, microwaves, semi-conductor devices, magnetic amplifiers, jet propulsion, nuclear energy, some of which were war-born, have introduced new information, new theory, principles and applications into college work. As a specific example, microwaves and their associated wave guides have brought Maxwell's electromagnetic equations into undergraduate classrooms and required an extension of mathematical preparation to comprehend the analysis and understand the behavior of these ultra-high frequency systems. Another example is the digital computer which has good and bad effects on engineering colleges--good because of the intellectual stimulus and broadening of the mathematical base of engineering; bad, because much time can be wasted in a maze of details which are apt to be transient in the fast moving computer game. The computer is being recognized by structural engineers as a powerful tool for analysis and design. Many alternative designs can rather quickly be studied and the effect of changing parameters can easily be learned. Hence, optimum designs can be identified without prohibitive cost in engineering time. More

thorough analysis will allow closer approach to ultimate limits with assurance and comfort. These advantages will motivate Civil Engineering students toward more mathematical competence in the understanding of computer logic and techniques for later use. Similarly, a broader mathematical foundation will strengthen a designer's capability in dealing with dynamic structural problems arising from transient loads of traffic, wind, earthquakes or blast. And, closely related are the vastly improved instrumentation techniques for static and dynamic stress determination, experimentally, during construction, and periodic measurement during the life of a structure. Strain gages and other transducers are now found in college testing laboratories along with their necessary electronic amplifiers and recorders, broadening the student's horizons to include more comprehension of basic electrical engineering. Rapidly this modern instrumental approach is transforming the traditional "busting laboratory".

Obviously, education can't go in all new directions at once. Colleges should not attempt to meet these challenges by detailed specialization in all of these new and emerging areas of current interest and importance. Instead schools must do the more difficult job of examining each new development for those features that are truly basic, extracting the concepts that are new and fundamental, and synthesizing the important generalizations that have lasting value. This exercise of self-discipline, sticking to fundamentals, is not easy. The other course, that of following avidly in the classroom the exciting new developments, the intriguing applications, and the fascinating new details, is more fun, has high entertainment value for the student, and is an easy, pleasant way to teach. But, it has the elements of a phoney gold brick, the superficial appeal—the form, but little substance. The values are apt to be transient.

Thus, in appraising new developments, engineering colleges must evaluate critically the fundamental character of these new advances—what is now involved and what is anticipated—so that curricula and course content of the basic sciences and engineering sciences may be improved as fundamental education for future professional application. Teachers must always be critical of that instruction which is specialized training rather than comprehensive education.

The business of a university is to teach principles, not practice. Details are to be regarded as illustrations of the application of the principles. With such underlying philosophy we can make our engineering teaching have much broader professional scope. An example is Systems Engineering.

Systems Engineering describes good engineering procedures for achieving an optimum design or synthesis of a complex system including the environmental factors and the people concerned in its operation. The basic principle is inherent in all good engineering and it was well stated some 70 years ago by A. M. Wellington in his classic volume, "The Economic Theory of Railway Location". Wellington has this to say about Reconnaisance, which one might paraphrase to apply to a system. "That, however forbidding the region, a line exists which is conspicuously better than any other, and which will in all cases be found to be—in comparison with what was expected—a line cheap to build and economical to operate; and that, on the other hand, the line which he, as an inexperienced man and acting without special training for the work, will be likely to first select as the best, is perhaps twice as costly in first cost and considerably less favorable in gradients and operating value than that which he can secure by greater care, attention and study. Although this

may seem a sweeping generalization, it is so near a general average of probabilities in both easy and difficult country, that in a rude way it may be assumed as truth."

It is indeed ironical, then, that within Civil Engineering, itself, narrow professional specialties inhibit the broad thinking outlined by Wellington. One of our Caltech faculty is currently assisting in the Program of the Hydraulics Division for the 1959 ASCE National Convention in Los Angeles. He notes that: "A very interesting paper has been proposed on a new procedure in evaluating aqueduct routes. Because this paper cuts across the fields of several committees and several divisions, there appears to be no place for it on the program." What has happened to our broad engineering principles?

Such broad principles are of value to electrical engineers, mechanical, civil, aeronautical, alike. These are the things which make real engineers, and, difficult as it is to do so, these strong unifying influences must be identified for the students.

Hence, the Report of the ASCE Task Committee on Professional Education is a bit discouraging. Conclusion (1) states:

"Civil engineering has certain characteristics which distinguish it from the engineering profession as a whole. Among these are breadth of field and the responsibility for economic planning, greater concern with public works and with countless structures serving the public welfare, and the development of plans and programs extending far into the future."

Followed by the recommendation, which is:

"Although certain undergraduate courses are commonly required for all students in engineering,—civil engineering curricula must maintain their separate identity and objectives and the civil engineering departments of our colleges should receive support consistent with the civil engineer's great contribution to society."

This attitude has long been a part of the philosophy of Civil Engineering education and it has a measure of validity. However, other fields of engineering also can fit into this broad context. Mechanical and Electrical Engineers, together with the many other variant forms of engineering practice include long-range planning, responsibility to the public, and economic planning. The engineers in an automotive company who are engaged in the advanced designs are making plans for at least five years ahead. This may involve an entirely new factory with its integrated facilities, and, as an example of detail, an engine block design which is capable of progressive modification, rather than complete redesign as yearly models come along. Aircraft engineering is on an equally long time base with six or seven years elapsing from the concept and performance specifications of a new plane until it is operational. Public safety and health at altitude present problems of considerable magnitude, as well as relationships with federal and other regulatory bodies, not to mention compatability with radio navigational systems, communications and airport facilities.

Engineers in industry are more and more assuming positions of managerial responsibility and along with financial and legal talent are shaping corporate policy. This involves very long-range planning including many of the features that are normally associated with Civil Engineering projects.

It is not at all uncommon in large corporations as they expand to decentralize and establish new plants in communities where that type of industry may not have existed before. This is done for reasons of

decentralization to tap new labor markets, to achieve better living conditions for employees. As a specific example an Electrical Engineer a few years ago was told by his company management that they wished him to be the manager of a new plant for which he would have complete responsibility for design, construction and operation in a community which had essentially no industry at that time. This Electrical Engineer spent many months in negotiations with the local Chamber of Commerce, the banking interests, the city officials, the school officials, railway and highway people,—to plan for the various services and utilities which would be required by this multi-million-dollar plant and for the housing and school needs of the several hundred key employees who would be moved to this community. This kind of breadth is needed in many engineers who are facing similar problems in our expanding technology. More and more community problems of government, schools, recreation facilities and other environmental factors become key issues with employees who are being asked to move to new locations and the Engineering Manager must be very alert to these factors and have working with him people who are skilled in such matters. This and other attributes dealing with people and the attendant responsibilities should be marks of any truly professional man. By implication in this ASCE conclusion and recommendation, the Civil Engineers suggest that other engineers are less concerned than they with public works and structures, serving the public welfare and the development of plans and programs extending far into the future. The ownership is irrelevant.

A chemical engineer friend of the writer started eight years ago for his company to develop processes for a plant for production of chemicals from coal as raw material. This has been a truly long-range development beginning with a new concept of remotely controlled mining of the coal, conveyor transport for some thirty miles, and processing as feed stock for the plant. This even involved negotiations and agreements with the union of mine workers who would not be needed! In parallel the chemical laboratory work was proceeding, leading in turn to the design and construction of the pilot plant. Concurrently preliminary design proceeded on the production plant. Electrical power, water supply, waste disposal, gas and chemical storage, fire protection, plant safety, instrumentation and control, transportation, all presented special problems involving not only the company but the community as well.

The Mechanical and Electrical Engineers are planning years ahead for electrical power developments and communication systems to meet the needs of our growing technology and are raising standards of living. Buildings both public and private have come a long way from being simply structures more or less decorated in which people worked and lived. Now within these structures we create a proper environment for the purposes of the building with lighting, air-conditioning, communication and transportation devices of considerable complexity. One has only to look at the breakdown of costs in a modern building to see that the major effort goes into the mechanical and electrical aspects of the building and only a small fraction into the structure. People live and work in this artificial environment and it must be right. As one Mechanical Engineer who built a very large and successful manufacturing business has said: "The most expensive thing I buy is my employees time and if by additional investment in a better environment I can get only a slight improvement in work efficiency, I will be ahead."

No, it cannot be defended that some of these qualities of a good Civil Engineer are no longer unique to Civil Engineers, and as a consequence—are the various Engineering departments wise in trying to maintain artificial distinctiveness? Also, thoughtful teachers recognize that many of the qualities which make an engineer effective in dealing with the public, government officials, boards of directors, and so on, are not the result of study of college courses, but are due to his genes.

In general engineering work is becoming complex, requiring broader scale systems thinking and analysis. This means that the responsible engineers must have rather broad knowledge of not only machines, but also the environment in which they must work and the men who will be concerned with their use. Students must learn to think more broadly than they have in the past. Not that they can expect to be experts in all technical fields, but that they have a wider knowledge of what exists in these other fields and where their own ignorance requires that expert help be brought in. Therefore students should not be allowed to grow up with the idea that Mechanical Engineers are markedly different from Electrical Engineers or from Civil Engineers, but, rather, that all are engineers with some specialized professional slant. It is in practice that the engineer develops true professional competence and specialized knowledge.

College teachers badly need help from the professional societies if students are to be convinced that unity in the profession is possible and that it is wanted. Do students see an attitude that is really professional and not merely provincial? Much can be done in our engineering curricula to develop better attitudes toward unity without abandoning our engineering "options". This is accomplish by minimizing differences, developing similarities, common subject matter, common principles. Teachers can interchange across departmental lines and develop broad systems thinking. Functions can be stressed rather than the traditional specialized disciplines to which the modern engineering world no longer conforms. Schools must provide better engineering <u>education</u> and not specialized <u>training</u> if professional stature and with it professional unity are to be achieved. Teachers need your sympathetic understanding and active support. Then—to return to the title of this talk—we can have Education as if <u>Effects</u> Unity in the Profession.

Paper 1870 December, 1958 PP 1

Journal of
PROFESSIONAL PRACTICE
Proceedings of the American Society of Civil Engineers

PITY THE POOR PROFESSORS? — OR PROPAGATE THEM![a]

J. E. McKee,[1] M. ASCE
(Proc. Paper 1870)

One of the greatest problems facing the engineering profession today is the shortage of competent engineering faculties!! Already serious, this shortage will become acute early in the next decade when the high birthrate of war-time and post-war years causes enrollments at the college level to soar. Children born in 1940 are already at college age, and increasing numbers will be knocking at academic doors for at least 17 more years. The U. S. Office of Education anticipates an increase of 70% in total college enrollment from 1956-57 to 1966-67, while the Committee on Development of Engineering Faculties (CDEF) of the American Society for Engineering Education (ASEE) predicts a 69% increase in engineering enrollment during the same period.(1)

The Need for Engineering Teachers

A recent survey of high school students in San Diego County(2) showed that about 25% of the boys and 5% of the girls were interested in science and engineering. A large proportion of these students rank in the above-average and presumably college-eligible group. At present, according to the CDEF report,(1) the engineering enrollment is 23.7% of the total college population, and by 1966-67 this percentage is expected to increase to 26.2%. In California, figures from the Department of Education show that from 1951 to 1956 the high-school enrollment in beginning algebra increased from 49.4 to 59.3%, in plane geometry from 33 to 40%, and in chemistry from 25 to 30%. These data strongly suggest that future college populations will contain significantly increased percentages of engineers and scientists.

The combined efforts of many agencies have been successful in selling careers in engineering and science to high-school students, even before the "sputniks" dramatized our need for such personnel. No longer need we worry about an adequate supply of new blood for our engineering colleges (although there are serious reservations about how well these youngsters have been

Note: Discussion open until May 1, 1959. To extend the closing date one month, a written request must be filed with the Executive Secretary, ASCE. Paper 1870 is part of the copyrighted Journal of Professional Practice, Proceedings of the American Society of Civil Engineers, Vol. 84, No. PP 1, December, 1958.

a. Presented at the June, 1958 ASCE Convention in Portland, Oregon.

1. Vice Chmn., Committee on Engineering Education, ASCE and Assoc. Prof., San. Eng., Calif. Inst. of Tech., Pasadena, Calif.

trained on the elementary and secondary levels!!). Our present concern is how to educate these potential engineers properly so as to improve our graduates in quality as well as quantity. New buildings, equipment, and other physical facilities can be erected or procured in a year or so but high-grade college faculties cannot be created overnight. To provide effective education for the anticipated large increase in engineering enrollment, with proper allowance for death, retirement and other attrition of existing faculties, the CDEF estimates that 9500 new engineering teachers will be needed in the next decade. This number of new teachers is approximately equal to the staff of present engineering faculties.

The development and maintenance of engineering faculties have been compared by Dean Everitt(3) to the seed problem in agriculture. Every farmer knows that a portion of each crop should be saved as seed for subsequent years. Furthermore, the small part of the crop needed for seed should be the best and most vital, and it should be most carefully nurtured and kept. Only by such selective processes can the quality of future crops be improved. So it is with engineering. Each of us in the profession should urge, or even insist, that the best students remain in the academic role to improve future crops, to raise the standards of technical proficiency, and to add to our store of fundamental knowledge by research. It is shortsighted for industry, practicing engineers, and government to lure the best students as soon as they receive bachelor's degrees, thereby discouraging them from entering graduate school, which is generally a prerequisite for a career in teaching.

Reasons for the Shortage

Why do we have a shortage of competent engineering faculties? The answer that comes to mind immediately, and the one most frequently quoted, is that engineering professors don't make enough money. While this reason may be valid in many instances, the total answer is not quite so simple, nor as easily remedied.

One major reason has been mentioned already. For the past 18 years, most of our best students have been lured into high-paying jobs as soon as they obtained bachelor's degrees. Facing an offer of $450 a month or so, it is difficult (and a real sacrifice) for a young engineer to spend 2 to 4 more years of graduate work, even with an assistantship at $150 a month — especially if a wife and child complicate the picture.

Parenthetically, the generation now in its forties will recall that this situation was not always true. During the depression, jobs that were scarce and much in demand paid only $100 to $125 a month while a graduate fellowship or assistantship provided $1000 for a 9-month period. Is it little wonder that our best seed crop in those days returned to graduate school and subsequently entered the teaching field?

Another part of the answer lies in the fact that young engineers in the 22- to 28- year age bracket are truly in short supply. These men were born from 1930 to 1936, the depths of the depression, when the birthrate was at its lowest. Worst yet, this is the age group that was advised by high-school counsellors to shy away from engineering. As a result, the present group of graduate students and young engineering teachers is at a low ebb.

Some insight on the current shortage of competent engineering professors can be gained from a recent survey(4) of deans to determine why engineers

have foresaken the academic life for other work. Financial considerations, to be sure, ranked as the predominant reason given by the deans; but there were others more subtle and masked. Some educators are not content in the sedentary life, especially in smaller towns; others are disappointed in the frequency of promotions; incompatibilities arise within small staffs; sometimes the future doesn't look too promising; and often the wives are unhappy about some aspect or other in the restricted college community. Faculties are not unlike many other categories of livelihood where human relations and aspirations are involved.

The biggest reason for the shortage of competent engineering faculties can be blamed on the professors themselves! By an attitude of self pity and public lamentation they have convinced everybody, including the seed for future crops, that college teachers are downtrodden, underprivileged, and underpaid. Nothing could do more to scare away the potential young graduate student who had hoped to go into teaching. To quote Dean Everitt,(3) "while this wailing may at times be justified, I feel that it has seriously reduced the prestige and status of our profession. Dead martyrs are revered, but live martyrs are avoided, especially self-designated ones." If this situation does exist, moaning and whining about it will certainly not help to cure it. Instead, they will only aggravate the problem.

Salaries and Earnings of Engineering Professors

How true is the contention that college engineering professors are poor? Before considering actual statistics, each reader should pause and reflect about the various professors he knows, the ones who have made a career of teaching, who have reached the rank of full professor and an age of 50 or so. What sort of houses do they occupy? What kind of cars do they drive? What eminence have they attained in the community and in the profession? Do their children go to college? In short, do they live like downtrodden, underprivileged, underpaid citizens? Among my own acquaintances, in California and elsewhere, the answer is generally negative.

With respect to eminence in the community and in the profession, it is well to invite attention to the prominent part that engineering educators play in ASCE affairs. Many of the past presidents of the Society have been professors and deans, and the representation of academic personnel on the Board of Direction far exceeds the percentage of engineering teachers in the total membership. Finally, the Technical Divisions of the Society and their many committees rely heavily upon the voluntary assistance of civil engineering professors.

In place of opinions and personal acquaintances, let us look at some statistics and surveys. On the basis of Report No. 102, "Professional Income of Engineers, 1956" of Engineers Joint Council, the median engineering teacher does about as well financially throughout his life span as the median engineer in all phases of the profession. The words median are underlined purposefully, for the professors who represent the best seed of former crops should obviously fare better than the average. The top engineering professors — presumably those who end up as department heads or deans — do somewhat better financially than the median, quite obviously, but not nearly as well financially as the top administrators in civil service, the heads of consulting firms, or the captains of industry.

A survey by NSPE[5] of income and salary of registered engineers throughout the country in 1956 showed that teaching ranked below executive and administrative work, below sales, and below research and development but ahead of design, production, and the supervision of construction. The salaries of registered engineering professors were near the national median.

The aforementioned CDEF of ASEE conducted a survey and issued a report in 1957 that tabulated the average incomes of engineering teachers of various ranks in state universities and in private schools for 1956. This report was especially significant because it gave the outside remuneration of teaching personnel as well as their academic salaries. Table 1, abstracted from page 5 of that report, shows the mean annual incomes and teaching salaries of all engineering teachers in both public and private institutions.

Table 1. Mean Annual Salaries and Incomes of Engineering Teachers (from ASEE Report, 1957)

Rank	Basic Teaching Salary*	Outside Income	Total Income
Instructor	$ 4,258	$ 1,094	$ 5,352
Asst. Prof.	5,384	1,878	7,262
Lecturer	5,422	2,144	7,566
Assoc. Prof.	6,554	2,293	8,847
Professor	8,538	3,113	11,651
Dept. Head	9,320	2,218	11,538
Dean	11,211	2,496	13,707
Mean for all Respondents	6,634	2,228	8,862

*These figures do not take into account variations among schools in the number of months of teaching.

Basic teaching salaries were slightly higher than the mean in private institutions and slightly lower in state universities; but the differences were ±5% or less. Outside incomes, however, were considerably higher for teachers in private than in public schools, especially in the higher ranks. These differences are probably attributable to the fact that most private institutions are located in large metropolitan areas where consulting opportunities are frequent, whereas many state universities are situated in small communities. Moreover, state universities may be more restrictive with respect to consulting.

It is interesting to note that the average total income of full professors was slightly higher than that of department heads, owing to more outside remuneration. It is also significant to express outside income as a percentage of the academic salary, as shown in Table 2. These percentages reveal that the average engineering teacher may expect to earn from outside sources an amount equal to about one-third of his academic salary. Professors and associate professors in private schools generally receive outside incomes equal to about half of their regular salaries.

Not all of this outside income comes from consulting work and other activities during the academic year. Much of it represents remuneration for summer work when school salaries are stopped. The CDEF report for ASEE contains a tabulation of true monthly teaching salaries by rank, i.e. the annual salary divided by the number of months worked. It also compares "annualized" teaching salaries (monthly salaries times 12) with total incomes, the difference representing outside income in excess of a 12-month salary. On this basis, the mean outside income as a percentage of academic salary for all respondents in public universities drops from the 27.9% in Table 2 to a mere 3.3%. For private schools the corresponding drop is from 45.9 to 17.2%.

From the foregoing surveys and statistics it is apparent that the earnings of the average college engineering professor are as high as the median engineer in his age bracket, or perhaps slightly better when outside income is considered. On that basis, should we pity the poor professors publicly and thereby scare off the best young engineers who are needed so badly now to build up our inadequate faculties? Certainly not. We should encourage the best of our present crop to remain as seed for propagation of expanded and improved academic staffs!!

Table 2. Outside Income as a Percentage of Academic Salary (data from ASEE Report, 1957)

Rank	Public	Private	Total
Instructor	24.7	28.3	25.7
Asst. Prof.	30.2	43.3	34.9
Lecturer	39.5	39.8	39.6
Assoc. Prof.	28.9	53.5	34.9
Professor	29.2	52.1	36.5
Dept. Head	18.8	36.9	23.8
Dean	15.0	37.0	22.2
Mean for all Respondents	27.9	45.9	33.7

Additional Financial Incentives

While wailing and pity are scarcely justified by the statistics of average income, should we expect our best seed for future engineering faculties to be content with median salaries? These are the young men at the top of their classes scholastically, the men most likely to succeed in private enterprise or government organizations, the men who should be in the upper quartile or upper decentile of the profession. To ask them to sacrifice earnings for two to four years of graduate study and then remain at the median salary level throughout their lives is certainly unjust and unrealistic. If we expect to entice our best seed for the propagation of future crops, we must make a career in teaching as financially attractive as the better-paid positions in administration, management, sales, and consulting.

How can the total incomes of engineering faculties by improved? The answer that comes first to mind is to increase academic salaries; but it

involves many corollary problems. Private colleges are non-profit institutions that operate largely on the income from restricted endowments. It is becoming increasingly more difficult to raise large endowments in the face of high taxation and limitations on donations. The portion of income derived from tuition can be increased and it should be, in many instances; but tuition provides only a small part of the total operating income of most private engineering schools. High tuitions place private colleges at a slight disadvantage with respect to state universities when competing for the best brains.

The budgets of public universities, on the other hand, are dependent largely upon annual appropriations by the state legislatures — political bodies sensitive to many pressure groups interested in keeping taxes at a minimum. Furthermore, salaries in public schools are based almost solely upon rank and longevity, regardless of specialty, rather than upon supply and demand. Thus, a professor of history makes as much as a professor of engineering despite the fact that history teachers are plentiful and seldom subject to proselytism by industry.

Irrespective of the roadblocks, pressure should be maintained for increases of engineering faculty salaries. Individual members of ASCE, and local sections as collective bodies, can assist such pressure by urging state legislatures to raise salaries in public universities, which, in turn, will be reflected in private colleges. Our more affluent colleagues in ASCE can help by contributing to the endowments, scholarships, and development funds of private institutions. The long-term trend of such actions will be favorable but they will not solve the immediate problem.

What, then, can be done in the next few years? The best immediate solution is to help engineering teachers augment their outside incomes. The opportunities available for extra-curricular work vary with geographic location, the specialty of the professor, and his aggressiveness. Some professors are quite reluctant to seek outside work. Indeed, many academic personnel, living in ivory towers, may be likened to "Engine-Charlie" Wilson's well-known kennel dogs.

To help engineering professors improve their outside income, it would be well to consider the present sources of such funds. Consulting represents the highest and most remunerative form of outside work. Most schools allow a faculty member to spend an average of one day a week in professional consultation. Here it is best for professors to work for or through established consulting engineers and not in competition with them. In the past, some professors have entered into the practice of engineering, to the extent of preparing plans and specifications for construction, but such competition should be discouraged by the ASCE, the consultants, and the colleges alike. The professor can provide a distinct and unique service as a consultant's consultant, or an advisory consultant. In such a capacity, it is best that he be placed on a regular monthly retainer rather than on a haphazard per-diem basis. He can serve effectively as an adviser to manufacturers and producing industries, as well as to practicing engineers.

Another source of outside income is the preparation, editing, and review of textbooks. Several engineering texts have been phenomenally successful and remunerative, such as French's "Engineering Drawing" or Johnson's "Materials of Construction." Others have brought in tidy and steady sums, especially when the books were revised frequently. In general, however, textbook writing is a labor of love, with little promise of sizeable financial return. Some professors prefer steady service as an editor or reviewer for a technical magazine or publishing firm.

A few positions with financial remuneration are available as secretary or treasurer of honor fraternities and local sections of engineering societies. Again, however, the return is not commensurate with the time and effort involved.

Outstanding professors are called upon frequently to serve on advisory boards for federal, state, and local agencies. Most of these positions pay $100 a day or even more. There are some public officials, however, who expect professors to donate their time and efforts on such boards as a public service. This attitude should be corrected immediately in the minds of all concerned.

Government, industry, and private engineering firms should take the initiative to employ more engineering professors in various advisory capacities. Everyone will benefit from such action. The employing agency will benefit, for it will have access to topflight brains trained in the latest theory and knowledge. In comparison with the expected returns the cost will be relatively minor, especially with no overhead, retirement, social security, and vacation pay involved. Furthermore, the employing agency will have contact through the professor with his best students as prospective future employees. In many ways, the employing agency gets more from part-time employment of faculty members than the other parties involved.

The professor will benefit in several ways. The added income will enable him to remain in the academic role that he has chosen as his life's work. Also, it will bring him in contact with realities in the practice of engineering to supplement his theoretical approach. The student will benefit from the better-rounded experience and outlook of his professors and from easier contacts with prospective employers. Finally, the school will benefit if, by these arrangements, it can attract and hold better faculties.

SUMMARY

It has been the intent of this dissertation to point out the need for expanded and improved faculties of engineering, to explore reasons for the current shortage of competent professors, to examine the salaries and other income of engineering professors, and to analyze methods for retaining outstanding young engineers in the academic community. To summarize, it is recommended that each segment of the engineering profession cooperate to overcome the shortage of competent engineering faculties by the following actions:

1. Professors should urge their best senior students to go to graduate school and to prepare themselves for a teaching career. The best graduate students should be encouraged to continue for doctor's degrees.

2. Students in the upper quarter of the class should think seriously about teaching as a career. It has many advantages. Anyone who has the aptitude and desire to teach need not be discouraged by the financial returns, especially if he is willing to do outside work.

3. Consulting engineers should each add a few professors to their technical staffs and hold them there by equitable monthly retainers. The consulting engineers, as well as the professors, students, and colleges, should benefit greatly from this arrangement.

4. Government agencies, on federal, state, and local levels should retain more professors on an advisory consulting basis. Where shortsighted civil-service regulations and closed-door protectionist policies prevent such consulting, they should be amended.

5. Industries, equipment companies, trade associations, and contractors could benefit greatly from stimulation provided by part-time employment of professors. Again, monthly retainer fees are indicated to assure a continuity of effort and allegiance.

6. National societies such as ASCE can help by acting as clearing houses for professors and potential part-time employers who have difficulty making contact. Engineering teachers in rural areas lack the opportunities for contact with prospective firms. Yet, many isolated professors can serve in several capacities -- as long-range advisors to equipment manufacturers or to trade associations, as editorial assistants or authors, as officers of national or local technical societies, and in many other ways. ASCE can also assist by local section action to persuade state legislatures to raise engineering salaries in public universities.

CONCLUSION

The shortage of competent engineering faculties, already serious and bound soon to become acute, will not be overcome by self-pity and public wailing over the poor economic plight of teachers. Indeed, such action will aggravate the shortage by driving away the best young graduates who should be returning to the academic life as seed for future crops. Surveys and statistics do not support contentions of poverty nor justify public pity, for teaching in an engineering school can be a rewarding life. Yet, financial inducements should be improved if our best seed is to be retained. To solve the shortage of competent engineering faculties, all segments of the profession can pitch in to assure that salaries are raised and that the outside incomes of professors are sufficient to make teaching attractive to our best young brains.

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IMPORTANCE OF EMPHASIS IN CIVIL ENGINEERING EDUCATION

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(Proc. Paper 1871)

The disconcerting facts presented by the Task Committee on Professional Education* were sensed by the ASEE Committee on Evaluation of Engineering Education several years earlier, but proof was lacking. A great service has been performed by the Task Committee in bringing to light the following attitudes which go a long way toward explaining why the profession of civil engineering, relatively speaking, has been losing its attraction to young men. Junior grade civil engineers voted 3 to 1 that the public considers other branches of the profession more important than civil engineering; and on a 3 to 2 basis they agreed with that opinion. In confirmation of this view those who are best able to compare and contrast the differences in educational values in the curricula of the several major branches of engineering, i.e., the deans of engineering schools, voted in a ratio of 10 to 1 that civil engineering is the "least promising" over the "most promising" branch for the future of students.

It is also significant to note that in a ratio of 11 to 1 the deans of engineering voted for electrical over civil as the most promising field of study for the future of students. Even if the votes of deans who preferred not to commit themselves are divided equally between the branches of engineering, electrical still outpoints civil by 3 to 1. The writer believes that deans weigh two main factors in arriving at such a decision. One is a factor partly but not entirely external to education, that is, the comparative volumes of research and development work leading to new engineering tasks. The other factor encompasses the educational values inherent in curriculum and teaching that prepare students to assume responsibility for new tasks. The deans obviously believe that these factors combine favorably in electrical engineering and are not sufficiently present in the profession and the education of civil engineers. Even if this is true today, it need not be true tomorrow, but the only place to change it is in the education of future civil engineers.

Note: Discussion open until May 1, 1959. To extend the closing date one month, a written request must be filed with the Executive Secretary, ASCE. Paper 1871 is part of the copyrighted Journal of Professional Practice Division, Proceedings of the American Society of Civil Engineers, Vol. 84, No. PP 1, December, 1958.

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* Civil Engineering, February, 1958, p. 111.

Breadth of Useful Knowledge

After recognizing the serious implications inherent in the relative lack of enthusiasm expressed for the future of civil engineering as a profession for young men, the Task Committee analyzed the varied demands for knowledge that come upon civil engineers. These demands go beyond engineering science, analysis, and design to include a knowledge of construction art, financial and legal planning, socio-political relationships and the development of judgment permitting the civil engineer to operate "beyond the well documented but relatively limited areas of systematized knowledge." This is the survey approach used by most analysts of education. Surprisingly enough, such a survey of job requirements usually ends by justifying almost every existing curriculum. If we apply the same type of survey to life adjustment problems of high school students, the results provide justification for a study of driver education, personality development, family life, and applied recreation while substantiating less effectively the critical need for more study of mathematics, English, science, languages, and history. Even in college we sometimes try to teach judgment before knowledge has been acquired through study of hard-core academic subjects. The loss, which is not so obvious, is that the academic courses provide tools for future thinking about the most significant problems of life, particularly the new problems encountered in a rapidly changing world. It is the more scientific courses and the humanistic courses in the civil engineering curriculum that perform this service for the professional engineer.

Transferability of Knowledge

It is enlightening to consider civil engineering education from the viewpoint of its transferability to widely varying jobs. There is really no unified concept covering the "art of civil engineering." There was an art in railway construction which civil engineers studied long after railroads ceased to be built and even after the railroads ceased to employ appreciable numbers of civil engineering graduates. Nearly all present civil engineers studied highway construction and paving practices, but only a small fraction have transferred the art learned into job application. In such courses it is only the small content of engineering science and the rather limited practice in using engineering science in analysis and design of components and systems that is transferable on a reasonably broad basis. In the hydraulic field a course such as open channel flow may have considerably more transferability to industrial and defense applications as well as public works employment, and again this is due to its relatively high content of engineering science, analysis and design. Whatever content of such a course is devoted to means of hydraulic protection, such as riprapping or sandbagging, and other practical arts is essentially nontransferable.

Obsolescence Factors

There is another characteristic about the study of art or practice that should be discouraging to the educator. All such knowledge suffers from an extremely high degree of obsolescence with time. The art of concrete construction has changed with scientific understanding of the setting process,

with change in winter protection procedures, with air entrainment, with water removal techniques, with vibration, with reusable forms, with precast elements, with lift slabs, with prestress, with fast moving rubber tired vehicles, etc. No ten-year period has seen less than a near revolution in construction procedures while the art or practice taught the student via the textbook is usually more than a decade old.

When the factor representing change in the art, which might safely be given a probability of obsolescence factor of 50 per cent per decade, is combined with the probability factor that the student will enter the corresponding branch of the profession, which usually represents less than one-quarter of the civil engineering area, the over-all probability of a given student using art or practice taught in a given course may be expressed crudely as the product of a group of factors such as

$$0.5 \times 0.7 \times 0.25 \times 0.6 = 0.05, \text{ or one student in } 20$$

The first factor allows for the average obsolescence of the textbook and of the teacher's contact with the art; the second factor allows time for the student to graduate and pass the first stage of apprenticeship; the third factor represents a rough division of the civil engineering area into structural, transportation, hydraulic, sanitary, soils or foundations; the last factor allows for overlapping subdivisions such as steel, wood, and concrete within the structural area. The reader may change any factor to suit himself without changing the conclusion as to the small probability of direct usefulness in professional life of art or practice learned in college. This crude analysis may be summarized by the generalization that in each class in engineering perhaps one or two students may make direct use of the specialized art, practice, technique or rules of procedure covered by the textbook or expounded by the teacher. All the other students in the class must benefit first from the content of study material having a higher degree of transferability, such as engineering science, and second from training in the engineering methodology of analysis and design which is relatively transferable to other fields and does not require extensive study of art or practice.

Art Versus Academics

The type of probability analysis carried out above has at least the merit that it challenges us to set a use value on each bit of material introduced into the engineering curriculum. Why study English? It is nearly 100 per cent transferable to every engineering job including other college study, and it has no significant obsolescence factor. Mathematics has a high transferability to all positions in engineering analysis and design without appreciable obsolescence. What about engineering drawing? Taught as technique, drafting has a low transferability of use, but if taught as graphical language, it becomes an essential tool of every engineer. Where teachers understand this distinction the course has undergone radical changes. It is equally true that an analysis of many civil engineering courses from this viewpoint would result in rather extensive revisions. It is even possible that students are quite aware of this need for revision of courses and that their lack of enthusiasm for civil engineering curricula as they now exist was transmitted indirectly through replies to the questionnaire of the Task Committee.

A strong argument that the teaching of art must give way to the teaching of

more fundamental scientific and humanistic studies for civil engineers is found in the first of the recommended procedures of the Task Committee for strengthening civil engineering education.

"1. Recognize and make it clear to others that professional training is a continuing process in which experience is gained and judgment is strengthened and matured by practice, based on the fundamental scientific training supplied by the colleges. A four- or even a five-year college program can give only the general educational and the technical basis for professional training. The internship and the learning-by-doing must come from association with practicing engineers. The supervising engineer must accept his responsibility for the development of the young engineers under his direction. Demands from industry or consulting firms that engineers be thoroughly trained as technical aides when they report for their first jobs are impossible to meet without sacrificing other vital aspects of their education in professional responsibilities. Industry, as well as the practicing engineer, has an obligation to help the graduate obtain the balance of his professional training."

Taking Part in New Developments

Finally, we may look into the matter of glamour or publicity attached to the various fields of engineering to locate an additional factor that makes civil engineering less attractive to students than formerly. Why is the study of engineering a thrilling experience to so many young men? Hardly a paper is printed or a magazine distributed without an article on science and engineering as the background of the new way of life. But civil engineers should notice that the two words, science and engineering, are closely associated in the public press and hence in the public mind. Taken together over a decade and a half science and engineering have created a new world for man to live in. Which engineering curricula are closest to science? Electrical and aeronautical engineering use mathematics freely and emphasize their close relationships to physics. Each of these engineering curricula shows four times the percentage increase in student registrations found in civil engineering according to the Task Committee's report.

The attitude of civil engineering faculties, with important and notable exceptions, has been to require the minimum mathematics, physics, and chemistry permitted in any engineering curriculum. Thus civil engineers have been less prepared academically to work with scientists or to take part in new developments. Perhaps we have lost sight of the common observation that the greatest need for engineers is always on the frontiers of technology. Successively, we have passed the frontiers of technology in several areas of civil engineering. Techniques become standardized, specifications control design, and the result is less actual need for engineers, more use of technicians, and less attraction as an area of engineering employment.

The process of downgrading engineering employment, just explained, will become self-generating if civil engineering education finally should accept the theory that its objective is to prepare engineers for standardized practical work rather than employment on the frontiers of technology. Only engineers with strong scientific knowledge can be expected to create new frontiers within the area of civil engineering. Such engineers in the past have often come

from Europe and have then created new frontiers of civil engineering in the United States. We think immediately of Timoshenko, Bakhmeteff, Terzaghi, and others. Such engineers with strong backgrounds in mathematics and science, far beyond the requirements of a civil engineering curriculum in this country, were able to create new frontiers in civil engineering. It may not be happenstance that cylindrical shells, prestressed concrete, and thin shell paraboloid roofs were developed more rapidly outside than inside the U. S. A.

Reversing a Negative Cycle

When a downward self-generating cycle develops through neglect it can only be changed by rather direct action. Such action in civil engineering education might be achieved by a decision to hire scientifically trained teachers whether they be civil engineers, other engineers, physicists, or mathematicians until something of a balance between interest in civil engineering practice and interest in pushing back the frontiers of knowledge has been restored. This possibility is something of a break with tradition and therefore seems rather remote unless it should receive the support of the profession.

In terms of curriculum the changes needed can be indicated by changes in the Task Committee's Table 1 entitled "Suggested Curriculum for Undergraduate Civil Engineering." The several subdivisions will appear in nearly all civil engineering curricula. However, the relative emphasis upon these divisions is a more significant matter. This factor has been added by the writer. It was necessary to separate engineering art and design in order to indicate relative emphases. Also, since ROTC must appear somewhere it was added to Item III to which it is somewhat related as are the applied aspects of human relations taught in industrial engineering or in a department of business administration.

Reports of Curricula Changes Over the Past Five Years

Recently the writer was asked by the American Society for Engineering Education to review the changes of all engineering curricula in relation to the change in demands upon engineering graduates that are being produced by rapid developments in science and technology. Reports upon curricular changes over the past four or five years were obtained from more than one-half of the engineering colleges. This survey led to the accumulation of information summarized in Tables II and III. From Table II it becomes clear that engineering schools generally are increasing the required study of mathematics and physics for many engineers. In fact, as shown by the final column of Table II, engineering colleges, on the average, have strengthened at least one area of science background for engineers. Of course, there is no indication here as to the relative changes in civil engineering and other branches of engineering study.

In Table III we have summarized the changes reported by the deans with respect to the content of courses taught in the engineering colleges. Without going into detail, it is clear from Table III that the courses in the engineering science areas of mechanics, thermodynamics, heat transfer, fluid flow, electric currents and fields and the basic study of engineering materials are being increased somewhat in credit hours at the expense of courses in engineering practice or art and of other technical courses including ROTC. It is

TABLE I

COMPARATIVE CURRICULA FOR UNDERGRADUATE CIVIL ENGINEERING

	"A" Compromise curriculum with lack of emphasis. Typical of many present offerings.	"B" Increased emphasis on fundamentals. Reasonable achievement for the near future.	"C" Strongly fundamental curriculum. To put more Civil Eng'rs on frontiers of technology.
I. General Education (History, literature, sociology, philosophy, political science, basic economics)	20%	20%	20%
II. Means and Arts in Communication			
III. Applied Aspects of Economics, Finance, Law, Human Relations, and ROTC credit		small	none in 4 years
IV. Basic Science (including mathematics)	20%	25%	25%
V. Engineering Science	20%	25%	30%
VI. Engineering Art	20%	10%	small
VII. Engineering Design	20%	15%	15%
VIII. Elective Flexibility (outside of civil engineering)	small	5%	10%

TABLE II. CHANGES IN SCIENCE CONTENT OF ENGINEERING CURRICULA

Characteristics of the Engineering Colleges Reporting	CHANGES REPORTED IN MATHEMATICS CONTENT				CHANGES IN CHEMISTRY		CHANGES IN PHYSICS SCIENCE CONTENT		
	Diff. Equations Added for All Engineers	Diff. Equations Added for Some Engineers	Required Mathematics Strengthened	Required Mathematics Under Study	Chemistry Strengthened in Credit or Content	Chemistry Requirement Under Study	Required Physics Credit Increased	Physics Requirement Under Study	Science Content Added in One Area
Colleges that awarded Ph. D. degrees in 1952-55 (45 reporting)	8%	26%	49%	18%	11%	16%	40%	22%	134%
Colleges that awarded Master's degrees in 1954-55 (35 reporting)	11%	28%	34%	6%	11%	11%	37%	9%	121%
Colleges that awarded only first degrees in engineering in 1954-55 (26 reporting)	4%	19%	54%	15%	12%	4%	35%	4%	123%

TABLE III. ENGINEERING CURRICULAR CHANGES OTHER THAN SCIENCE

Characteristics of the Engineering Colleges Reporting	CHANGES REPORTED IN ENGINEERING COURSES OF ALL TYPES						HUMANISTIC AND SOCIAL SCIENCE SEQUENCE
	Required or Elective Courses in Engineering Science Increased	Required Courses Revised to Increase Content of Engineering Science	Engineering Analysis and Design Strengthened	Engineering Science, Analysis or Design Strengthened (Total of 3 previous columns)	Courses in Engineering Practice or Art or Other Technical courses Including ROTC Reduced or Eliminated	Engineering Curricula now Under Study	Required Credit Increased or Electives Provided
Colleges that awarded Ph. D. degrees in 1952-55 (45 reporting)	40%	29%	18%	87%	87%	58%	60%
Colleges that awarded Master's degrees in 1954-55 (35 reporting)	20%	31%	17%	69%	83%	54%	66%
Colleges that awarded only first degrees in engineering in 1954-55 (26 reporting)	12%	23%	19%	54%	65%	46%	58%

also true that there has been a noticeable movement to strengthen the content of courses in engineering analysis and design. Perhaps a more significant fact is that over fifty per cent of the engineering curricula are reported to still be under study despite the recorded changes of the past few years.

Doubtless the most startling trend brought to light by this survey is reported in the final column of Table III. Over 60 per cent of the institutions reporting indicated an increase in required credit hours of humanistic study in their curricula. One recalls that the Hammond Committee of 1946 urged the colleges to adopt a minimum figure of 20 per cent of each engineering curriculum as the minimum content of humanistic and social science study. The colleges gave only lip service to this recommendation immediately after World War II in that they commonly included such technical non-engineering subjects as industrial management, English grammar, applied economics, accounting, personnel administration and ROTC as a part of the social science electives. Since the re-emphasis upon humanistic study by the Report on Evaluation of Engineering Education in 1955, a major movement to broaden the education of engineers in the humanistic and social science areas has taken place. The fact that one of the most distinguished institutes of technology reports that "the humanistic-social study requirement remains at 22 per cent of the total engineering program, which is essentially the same as it has been for the past 35 years" is evidence that this trend need not weaken the technical capacity of engineering graduates.

Quotations Regarding Changes in Civil Engineering Curricula

(Taken from reports prepared by Engineering Deans)

The following quotations should give some indication of the direction in which civil engineering curricula have been evolving over the past few years. The reports on specific changes in civil engineering curricula were somewhat less extensive than for some other areas of engineering study. However, the trends were in the same direction of increased scientific and humanistic content. In particular, there is an obvious trend to reduce the credit hours allotted to courses that emphasize the art of practice and of routine computations.

"First of all in 1957 the entrance requirements were increased so as to include mathematics through analytic geometry."

"Trigonometry was taken out and made a high school prerequisite and replaced by another (advanced) 3-credit course in mathematics."

"Differential equations is a requirement for graduation in all engineering curricula. This was made possible by requiring trigonometry as an absolute entrance requirement."

"Calculus course work for civil and industrial engineering (was) increased by 20 per cent; now (it is the) same as for electrical and mechanical."

"Our Civil Engineering Department has thrown out several arts type courses, has increased its mathematics content to that required in all other engineering curricula, namely, through differential equations, and has quantitatively improved a number of its courses. This department is preparing for another curriculum change."

"Civil, industrial, and mechanical engineering have each added a course in differential equations to their requirements at the expense of engineering courses (total hours required were not increased.)"

"Civil engineering students go through ordinary differential equations for a total of 17.25 semester hours."

"The total credit hours in mathematics was increased from 18 to 21."

"During the last few years advanced calculus has been made a requirement in chemical engineering and civil engineering."

"Statistics will probably be offered to all students because our faculty believes that few experiments can be performed properly without the use of statistics."

"Civil engineering dropped nine courses and added nine courses. One of the latter was atomic physics."

"Every engineering student is required to take four semesters of physics. This is twice the physics previously required."

"All curricula have a course in nuclear physics, not previously required."

"Credits assigned to basic physics courses were increased from twelve to fifteen."

"Humanities have been increased from approximately 20 per cent to 26 per cent."

"Over 25 per cent of each engineering curriculum is devoted to elective, humanistic-social studies."

"The civil engineering program has been reorganized and several of the more applied courses have been dropped in favor of devoting more time to basic engineering science courses. A one-year elective course in the humanities has been added to this curriculum."

"Civil engineering dropped engineering drawing as a requirement. Structural drafting (was) dropped as a requirement but (is) recommended as an elective. Engineering materials (was) dropped and replaced by the chemistry of engineering materials. Humanities electives (were) changed from 3 to 6 required units."

"The Civil Engineering Department has dropped curves and earthwork as a course required for graduation and much of this material will be incorporated in the second course in plane surveying. This will reduce the time spent on plane surveying from 10 to 7 hours."

"The civil engineering curriculum has reduced emphasis on surveying, increased emphasis on the engineering sciences and included in the senior year a two semester approved technical elective as a senior project, preferably, or a sequence of two courses aimed to provide depth in selected fields."

"Civil Engineering - These curriculum changes have slightly increased emphasis on basic and engineering sciences, a substantial increase in humanistic-social studies, and little change in engineering analysis and design and in electives."

"Major revisions have been made in the civil engineering curriculum. Courses dropped include: structural drafting, engineering society, bacteriology, accounting, law for engineers. Courses added include: humanities - social studies, engineering science, electives."

"In civil engineering the reduction of the number of hours of surveying and structural design has the effect of reducing the amount of time devoted to application and skills, thereby increasing the time available for elective subjects. The increase in the time allotted to dynamics definitely strengthens the background of engineering science."

"For civil engineers there has been a reduction of 33 per cent in advanced surveying."

"Also in both civil engineering and electrical engineering, two of the three introductory shop courses have been dropped."

"The Civil Engineering Department has added as a requirement a course in electrical engineering. This will be for three credits."

"The Civil Engineering Department has gradually converted out old course in foundations to a modern course in soil mechanics. A well equipped soils laboratory is now in full operation."

"Speaking of civil engineering, there was a drastic reduction in surveying with an increase in the amount of electrical engineering, soil mechanics, and advanced mathematics, the last mentioned course for structural engineers only."

"In civil engineering, less emphasis on surveying and structural computations; more emphasis on structural analysis and structural design theory."

"The research activities have grown gradually but with more marked activity in connection with civil engineering."

Encouraging Prospects

Fortunately, discussion centering around the concept of "the engineering curriculum" or even "the civil engineering curriculum" is based upon a misconception. There are great differences in engineering colleges, in their curricula and in the outlook or objectives of their faculties. Several locations have continued over the years to prepare a considerable number of civil engineers for work on the frontiers of technology. We should honor such schools greatly because they have been the benefactors of the civil engineering profession and among the greatest benefactors of this country. By honoring them we would encourage other institutions to join this important group.

The reason why change is slow in education is that every teacher tends unknowingly to try to create students in his own image. Our country has not been attracting a sufficient number of the keenest scientific minds or of broad humanistic minds into civil engineering education. Hence we have not produced strong encouragement of scientific inquiry or of breadth of scholarship in the majority of our civil engineering departments. The report of the Task Committee shows that the profession of civil engineering is likely to pay a heavy penalty in prestige and growth unless it uses all means at its command to stimulate and reward educational progress. It would not strain the ASCE

to award a few $10,000 grants annually to civil engineering departments that had contributed to the advancement of the profession by progress in education or research. The rate of return on this investment might be exceptionally high. At the least, it would prove that civil engineering had become a true profession, since every profession must take a direct interest in its own education.

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SPUTNIKS, FLOPNIKS, AND ENGINEERING EDUCATION[a]

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(Proc. Paper 1872)

The title originally assigned to this paper was, "The Major Strategic Problems Expected to Confront the United States in the Next Decade." These problems can be epitomized by a simple statement: How can we survive as a nation that believes in the basic American concepts of democracy and Christianity?

The question before us as a nation is just that basic and just that brutal. No amount of wishful thinking will solve it; nor will the question cease to exist because we ignore it.

Self-examination is good for the soul. To be effective, however, it must reflect what others think, NOT what we think of ourselves. So as an American who has had considerable opportunity to look at this question through foreigner's eyes, the writer will play the Devil's Advocate to the best of his ability and be brutally frank. He will attempt to say what our foreign guests are too polite to say. He will try to present to you some of the questions, comments, and viewpoints frequently put to him by sympathetic serious-minded friends who are important people in their own countries which extend from the British Isles to East Pakistan.

As background for this problem, the reader should review the place currently occupied in the eyes of the world by the United States as compared to that occupied by the Russians. The so-called uncommitted areas of the world realize that this "Cold War" is a war of extinction, and that if they are forced to commit themselves to one side or the other, they must choose the one that gives the greatest evidence of leadership and virility.

There are many things about us that bother those who could be our friends:

First, they cannot understand why we Americans cannot learn to subordinate our prejudices in an adult fashion and see things as they are and not as we wish them to be.

Second, they cannot understand why we do not accept the fact that because others approach life from a different point of view, they are not necessarily

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wrong. It is always possible that the others may be nearer to the truth than we. It is pointed out that since the dawn of reason all men have sought satisfactory answers to the basic questions of life—what am I, where did I come from, why am I here and where am I going? From the search for answers to these four fundamental questions has sprung all religious and philosophical thought, and what might seem right to one does not have to be right for another.

Third, they feel that if we are to survive we must remove a basic fallacy from our economic thinking—the idea that we can have an economy of plenty indefinitely.

They point out that while the human race tends to increase by geometrical proportions, and agricultural products can be made to increase within limits, fossil fuels and mineral resources do not reproduce and are irreplaceably depleted in direct ratio to the demands made on them by the economy. Hence, if a society is to live long enough to earn a place in history it must place the conservation of its vital irreplaceable wealth at the highest priority. The Russians claim that an "economy of scarcity" is the key to survival and eventual world domination.

They believe that deficit spending and designing for obsolescence can only lead us to financial and material bankruptcy—socialism and then communism.

Fourth, they feel that our national preoccupation with development, improvement, and standardization has so saturated our national thinking that we devote too much of our thought to how to do something better next time. It worries them that we are preoccupied with finding better ways to fight the last war or avoid the last depression or the last international crisis, while others are busy creating new events and thereby retaining the initiative. It is widely believed that if we are to survive we must place the ability to generate new creative ideas and concepts above that of the development and improvement of what exists.

Fifth, they feel that we still do not understand that the Russians have devised a new kind of war. Instead of seeking out the enemy's forces and destroying them, the Russian approach is to maneuver and encourage the enemy to destroy himself by exhausting his natural resources and dissipating his wealth and power in countering widely scattered military threats while the Russian ideology is sold to his enemy's population from within.

They ask, "Why must America accept the pattern of war thrust upon it by Russia—one which has as its prime objective that of causing moral, financial and material bankruptcy?" Haven't the Americans enough creative intelligence to devise another pattern that insures survival of their own way of life?

Sixth, it appears to the thoughtful foreigner that the present American social and economic structure no longer contains many of the basic American concepts that created America, and that many of those which we seem to have discarded have been effectively adapted by the Russians to their system.

Seventh, they remark that the American citizen at home and abroad, when faced with any unpleasant truth about his country's behavior, blames it on his government. Then they remind us that "People get the government they deserve", and they say that, if the people of America cannot get the government they want, the democratic theory is really nonsense.

Eighth, they cannot understand our apparent hypocrisy on the Middle East question. It is an accepted fact outside the United States that the only point of beginning for a solution acceptable to the Arabs lies in first enforcing the

United Nations partition lines of 1947 which the Israelis have violated from the beginning. Yet we persist in ignoring this fact.

In so doing we leave the ace of trumps in Russia's hand from which Nikita finesses effectively. By the union of Egypt and Syria there is formed a militant neutral third party control of the Suez Canal and the land barrier between Persian Gulf Oil and Europe. When Yeman joins the union, the Straits of Aden which dominate the southeast end of the Red Sea can come under this same control. Moreover, if the attempts to bring in Morocco and Oman are successful, the Straits of Gibralter and Oman could also pass to the control of these militant neutrals and with them the control of the Mediterranean Sea and Persian Gulf. The whole Middle East, including our bastion Turkey, could then be isolated without much effort, and NATO would be outflanked and neutralized.

When one considers the size and characteristics of the Russian fleet and its capacity to dominate all of the inland and coastal waters of the Eastern Hemisphere this development takes on a frightening aspect. If it happens, the U. S. will be effectively isolated from the Eastern Hemisphere, and the long term strategy of Peter the Great will have succeeded.

Also one must not overlook the fact that while this is going on in the Eastern Hemisphere, similar operations can be expected in South and Central America aimed at isolating us from the resources of our own front yard. Similar operations in the Far East and Pacific will be aimed at isolating us from the resources of our own back yard. It must be remembered that Sputnik has as great a "Red Herring" potential as regards global strategy as it has a genuine scientific potential with respect to space.

Unless we take the lead now in settling the Palestinian question, which is the major Middle East question, we can expect this new neutral group and all its influences to become increasingly more anti-American.

Although this possibility, which became evident with the revolution in Egypt, doesn't seem to worry us, it most certainly worries those we desperately need as friends and allies. They ask, "Isn't this risk too high a price to pay for a handful of domestic Zionist votes?"

Ninth, they point out that the American concept of democracy guarantees all an equal opportunity to compete, while the American concept of communism appears to guarantee equal participation to all who belong. Yet Communist Russia seems to follow this democratic concept in dealing with education, science and engineering, while Democratic America seems to follow its own definition of communism in dealing with education, labor and foreign aid.

And tenth, as they see us, we make a great noise about being Christian; but they see little evidence of it in our national and international behavior.

We point to our high moral and ethical code but we have very fixed notions about what is right and what is wrong, and we regard as inferior those who are different from us. They think we claim an exclusive possession of righteousness and morals which our behavior does not reflect.

On the other hand they accept the Russian at face value. He proclaims that he is an atheist and in explaining says that he does not believe in a personalized God nor in a life after death. He points out that he accepts the omnipotence of the evolutionary system of nature, and that his ideology is based on the positive evolutionary evidence of nature rather than on the abstract theory of some ancient mystic who personalized religion as a defense against fear. He maintains that true immortality comes from having done something sufficiently significant to deserve a place in history rather than it being individual

everlasting life hereafter. He will say that since immortality is a thing that must be earned in this life, rather than a thing to be gained after death, he has no fear of the hereafter, and that having no fear of the hereafter he is relieved of man's most strangling inhibition—fear.

To the uncommitted this is a powerful argument. One cannot deny that the Christian concept of life as practiced is based primarily on fear of the hereafter; and one cannot deny that fear in some form dominates our lives in the United States. Our present social economic system is built upon fear of discomfort, fear of ill health, fear of being judged different, fear of not being popular, fear of losing economic or social position, fear of not being an economic or social success, etc., etc., etc. Even bargain sales are advertised on the theory of fear of a lost opportunity. In contrast, the Russian maintains that no nation whose social structure is built on fear can possibly produce men of sufficiently uninhibited intellect to dominate the earth and the space around it.

Against this background Sputnik roared into space, apparently as a complete surprise to us. Why it should have been a surprise is difficult to understand. Surprise or not, it had a profound effect on the attitude of the world. This event increased the doubt of our ability to lead the free world, and the adolescent inferiority-based braggadocio with which we responded in the Press, followed by our failure to meet our claims, has caused everyone to reappraise us even more critically than before.

The Russian success in launching Sputnik I and then Sputnik II, followed by our unsuccessful attempts to launch the Vanguard—referred to in the rest of the world as "Flopnik",* has awakened us to the fact that we are engaged in a war of survival. While largely non-military this war is nonetheless total in every respect and one that we are not yet intellectually or psychologically ready to fight.

To date our reaction seems to have been largely confined to the military aspects. There seems to be an idea developing that this new space hardware will require a change in our strategic aims. That is, in the writer's opinion, false and dangerous. First, while new types of military hardware usually lead to changes in tactics, they should not change strategic aims unless they are faulty or incomplete. Second, since it is highly unlikely that the bulk of the human race will indulge in space migration in the next ten years, a sound global strategy should remain adequate.

If the world-wide suspicion that we have no crystallized global strategy is correct, then our most-urgent business is that of formulating one which considers nothing but the survival of what we consider to be worth preserving on this earth. Certainly if we have a crystallized global strategic plan, our diplomatic gyrations in international circles is doing a masterful job of concealing it. A would-be leader who behaves like a modern version of Don Quixote cannot attract intelligent supporters against one who clearly demonstrates that he knows where he is going and that he is getting there.

In the 1830's, Alexis de Tocqueville wrote in "Democracy in America" the following:

> "There are, at the present time, two great nations in the world which seem to tend towards the same end, although they started from different

*Editor's note: This paper was written and presented prior to the U. S. Army's successful "Explorer" satellites, but this success does not modify the author's arguments.

points: I allude to the Russians and the Americans. Both of them have grown up unnoticed . . . All other nations seem to have nearly reached their natural limits, and only to be charged with the maintenance of their power; but these are still in the act of growth. . . . they are proceeding with ease and with celerity along a path to which the human eye can assign no term.

"The American struggles against the natural obstacles which oppose him; the adversaries of the Russian are men; the former combats the wilderness and savage life; the latter, civilization with all its weapons and its arts; the conquests of one are therefore gained by the ploughshare, those of the other by the sword. The Anglo-American relies upon personal interest to accomplish his ends, and gives free scope to the unguided exertions and common sense of the citizens; the Russian centers all the authority of society in a single arm; the principal instrument of the former is freedom, of the latter, servitude. Their starting point is different and their courses are not the same; yet each of them seems to be marked out by the will of Heaven to sway the destinies of half the globe."

This prediction has been quoted many times. Seldom if ever is it used in what is believed to be the true prophetic intention of the author. What he says is still very true about both the Russians and ourselves. The Russians, for centuries, have been engaged in a struggle against all of the weapons and arts that civilization and its politics have developed, while we Americans on the other hand have grown up combatting only nature's wilderness. Like a farm boy, we have no significant experience with the sophisticated problems of complex international life.

Consequently, we entered the cold war with a completely naive attitude toward the world, against the most experienced and the most sophisticated international operator the world has ever seen. While we seem to have arrived at a national age of adolescent romanticism, Russia seems to have arrived at an age of mature Machiavellian sophistication. Russia couples this sophisticated maturity with a revolutionary vigor that is still gaining strength, while we couple our adolescent naivete with a status quo defensiveness which seems to have lost the revolutionary vigor that produced us.

We are engaged in a world-wide battle for men's minds and souls. The side that can discipline itself into producing the best intellects in sufficient numbers will earn survival. History has proved that only those survive who earn the right to survive. The judge in this deadly contest will not be any human tribunal; it will be the unrelenting impartiality of nature's evolutionary system itself.

Disregarding for the moment the other innumerable facets of this ideological contest, there is one vital facet that we must develop to its maximum if we are to survive. It is the capacity to produce creative thinkers, particularly in the fields of science and engineering.

We claim with considerable justification that we have an above-average national school system, that we have a very low rate of illiteracy, and that education is open to all. However, there is considerable evidence that this great school system including the state colleges and universities, geared to give the greatest opportunity to the greatest number, produces primarily an average product. While this may be very necessary to maintain our economic fabric, it does not, except by accident, develop our best intellects to their maximum capacity.

An analysis of the present Russian system, the intellectual products of which are startling the western world, provides much food for thought. Prior to the 1917 Revolution, Russian scientific and technological education, although confined largely to the aristocracy, was nevertheless very sound from an educational point of view. The concept of doing broad and deep original work survived the Revolution and the post-revolutionary Stalin years and it is now a major theme of Russian education.

It is the basic concept of Russian education that sound education must be made available to all those who demonstrate that they deserve it and have the intellectual capacity to use it, and that it must continue until they have reached the maximum of their intellectual development. On the other hand, the Russian holds that training is the development of a skill whether it be mental or physical and is something to which every member of the State must be subjected until he no longer improves; then he must be put to work at that level. This means that from the very beginning those who demonstrate intellectual tendencies are moved along toward education. As they demonstrate that they are approaching the limit of their intellectual capacity their program is shifted to training and there find their way directly into industry.

In common with most of the European countries they do not teach other languages as foreign languages like we do. Rather, they teach second and third languages and they start them at the beginning of school along with Russian. It is reliably reported that of the present study body in Russia below college level, 40% are learning either German or English as their second language, 20% are learning French, Spanish or Italian as their second language, and approximately 5% are taking one of the Asiatic languages such as Chinese, Japanese, Arabic, etc. In their preparatory work it is reliably reported that 53% of the total classwork is devoted to basic and applied mathematics, and to the full range of physical sciences.

With a selective system that constantly filters out those who are least qualified to continue, only the really promising students reach higher education. Although this percentage is small, the volume is not so small. For instance, in the academic year 1956-57 there registered in Russian schools a total of 35 million students, of whom 30 million were in the preparatory section while 3 million were in technical and scientific colleges and 2 million in general universities.

If the yearly output in engineering alone is related to population, Russia in 1957 produced twice as many as the United States, five times as many as the United Kingdom and four times as many as all the rest of industrial Europe. With the students currently enrolled, in 1960 Russia will turn out three times as many as the United States, seven times as many as the United Kingdom and six times as many as industrial Europe.

Although reliable figures were not readily available on the number of scientists being turned out, there is reason to believe that the numbers will approximate 75% of those given for engineers.

These figures may seem alarming, but they are not nearly as alarming as the apparent quality of the individuals produced. There is reason to know that they can be very good. While ours have been trained and taught to learn, theirs have been educated and taught to think!

The Russian system of making everyone earn intellectually what education he gets eliminates from the system all of the chaff that otherwise clogs it. To be of any value an educational system must have the basic characteristics of a threshing machine. Unless the chaff is first separated from the grain, it is impossible to select the best grain for germination.

On top of this basic approach the Russians have superimposed ideas that are basically American. It will be recalled that the American medical profession did an historic thing in regards to medical education. It decided that since it is a learned profession, it should establish its education and training within the discipline of that profession, and not follow the general academic system. It decided that instead of starting from the preparatory level as a base and then learning more and more about less and less, as you approach the top of the academic pyramid, it would permit no specialization below the Doctor of Medicine level in order that specialization would come only after a broad general cultural and professional base had been acquired.

The outstanding success of American medicine has attracted attention throughout the world and particularly in Russia. The Russians are not much concerned with the medical aspects of the preservation of life, since they regard human life as an expendable natural resource. But they were struck with the profoundness of this educational concept. As near as we can tell, they are using much of this approach in producing their scientists and engineers.

There was a very interesting recent article from a reliable source in Germany concerning the social climate within which Russian education is being carried on as contrasted with American procedure. It points out that in the Soviet economy, public consumption has no influence on production but that production is regulated solely to feed the development schemes of the government.

It points out that contrary to the wishful thinking in the United States, to the effect that the Russian people do not support the government's programs, and that the Russian Government is therefore bound to collapse, none of these government schemes could possibly have succeeded without the support of a dependable majority of the people. It also points out that the educational system makes great use of the Russian people's indifference to material possessions and is thereby able to develop a high degree of social prestige for the scholar, the scientist and the engineer. Finally, it points out that teachers are treated with the greatest respect and economic consideration.

The article contrasts this with American pre-occupation with creature comforts and material possessions. It is very critical of the lack of required solid course work in the preparatory schools, of the lack of discipline among American children, of the transfer of responsibility for personality development from the home to the school, and of the absurdity of requiring that all children until the age of sixteen attend public school, because of organized labors' unwillingness to drain off the least intellectually fit into apprenticeships in the trades and industry. It points out the low economic and social positions of the teachers and professors in the United States, and states that there is really no shortage of teachers in the United States, there is only a misuse of them in requiring them to try to teach too many who have no capacity to learn and who should have been physically trained to do something useful and put to work years before.

Another article points out that the major difference between the Russian approach and the American approach is that the Russians are participants while the Americans have become spectators. It notes that indoctrination in Russia is built on the idea that the national evolutionary growth of the Soviet now requires the replacement of the supremacy of Red soldiers with the supremacy of Red engineers and scientists. It observes that the Russian iconoclastic attitude of breaking traditions encourages new approaches to

intellectual development while the American slavish adherence to uniformity discourages new approaches to intellectual development.

During the early part of World War II, the writer was at one time responsible for selecting large numbers of engineers for appointment as officers in the Navy. To do this adequately it was necessary to become thoroughly familiar with all of the engineering curricula in the United States. Later in the Pacific, he had an opportunity to observe a large number of these same engineers in operation. Almost without exception the ones who turned out to be the most effective officers, who demonstrated the greatest capacity to handle men under unusual circumstances, and who demonstrated the greatest capacity for original thinking and ingenuity in unprecedented circumstances, were the ones who had had a broad and basic education in engineering. It seemed that the greater the specialization in application courses or in programs that were highly fragmented or that allowed full use of the so-called elective system, the more inhibited and ineffective in new circumstances the man became.

During 1946 while on duty in Washington, his assignment required that he again review all the engineering curricula in the United States, this time from the standpoint of quality and effectiveness. It was alarming to find that we were developing an even greater amount of undergraduate specialization and fragmentation.

During the time that he was Chief Engineer for the design and construction of the Argonne National Laboratories, the writer had some similarly enlightening experiences. The first difficulty was finding and assembling engineers who did not regard themselves as scientists and who at the same time did not regard real scientists as screwballs. Coupled with this was the equally difficult task of convincing the real scientists that they were not engineers.

Here again the same pattern that was observed in the Pacific became evident. The greater the specialization below the Doctor's level, the greater the man's inability to function in a new situation. Again, the most flexible and the most creative were those who had had the broadest general education.

Now, broad education does not mean a scattered sampling of introductory courses in the humanities and social sciences. Broad education means effective association with competent faculty who have the capacity to develop a student's desire and capacity to think by using the accumulated knowledge of the world as a spring board.

Since the 1930s, it has been increasingly apparent to many practicing engineers in the United States and abroad that our engineering educational system is fast becoming inadequate to meet the needs of our evolving society. The confusion that had developed up to 1947 led the late Dean Mortimer E. Cooley, Honorary Member of the American Society of Civil Engineers and of University of Michigan fame, to write in his autobiography: "For too many years the engineer has been limited, or has limited himself, to the making of the physical environment out of which have sprung the thoughts and actions of others . . . The engineer must be educated to the needed changes in his training which will enable him to take over the responsibilities of leadership that, by virtue of this technical civilization, are so largely his . . . It will be clear that I have no confidence in engineering educators, through their own organizations, to provide for the needs which to me are self-evident. I have come to the conclusion that the engineering educators cannot solve the problem; perhaps it is too close to them. The change in engineering will have to come from the profession itself."

In 1950, Henry M. Wriston, President of Brown University, in his address given at the inauguration of President Millis at Western Reserve University said: "The universities are in crisis also, because their fundamental philosophy is still dominated by Europe. In their formative period German scholarly procedures so captivated the minds of those who brought them home after training abroad that our graduate work, though diverging more and more, nonetheless follows the German model. Two wars revealed the weakness of German scholarship; magnificent in his precision, impressive in its thoroughness, it was markedly deficient in a sense of values. Amoral detachment left the road clear for immoral politics, domestic and foreign. Over attention to method with underemphasis upon values is a serious defect which American universities derived from their German inspiration . . . Moreover, as educational associations gained power, in the name of raising "standards", they subjected institutions to so many requirements that the determination of policy in certain areas is more external than internal. The disintegrating process has reached so advanced a stage that only the greatest administrative skill and firmness can reverse the trend."

It should be noted that the Russians had to make no adjustment in their ideology in moving from amoral German science, from which they have borrowed as heavily as we, to atheisticly based Russian science. On the other hand we Americans have to reorient our whole approach if we are to move from an amoral German science base to a new and effective base that is compatible with our Christian concepts.

This poses the problem that is the essence of our dilemma. Starting from an amoral approach to science how do we successfully compete with Russia's atheistic approach without losing our own Christian moral values? Money won't buy the answer to this question. But we must answer it and answer it right, if we are to survive as Christian America.

Since 1951 we have been carrying on a small controlled experiment in engineering education at the American University of Beirut in Lebanon. This institution is chartered under the Regents of the State of New York and operates to serve the entire Middle East. Within the limits set by seemingly unbreakable academic tradition, trustee reluctance, administrative apprehension, and faculty resistance to new things, we have put together a very broad basic program aimed primarily at putting into practice the theories which these past experiences and observations have formed.

The success of the graduates produced by this six-year basic program in engineering is most encouraging. They have out-performed the competition they have met in that international technical battleground which is the Middle East. Those who have come to the U. S. to do graduate work have all done outstanding work.

However, even at that distance from the United States and with a fair degree of isolation from American control, our greatest obstacle to date has been the fear of all concerned that we will be different. Educational experts from the United States including those of the large foundations praise our results while they deprecate our non-standard methods.

It has taken far more time and effort to find a way to be permitted to do what we have done, than it has taken to do it. The experience has taught the writer that the quest for uniformity in personnel and educational matters is a very frightening Frankenstein brought to life by the pedagogues and statisticians who call their creations the "standard criteria" and the "average man." They are creatures of the punched-card pattern, "standard" models that have

become the gods of mediocrity and the protectors of all incompetents who do not dare to compete with those who, having the courage of their convictions, dare to be different.

In this American age of standardization and uniformity, it takes a very considerable amount of moral courage and an enormous amount of energy just to be an individual. To be different, to do something in a new way, is all too frequently regarded as ample cause for criticism, denouncement, and even social isolation. Yet at no other time in our history has there been such great need, not only for those who can do old things in new ways, but above all for those who can do new things any way.

Throughout our experiment we have had the whole-hearted and enthusiastic support of the practicing engineering profession, American overseas industry, British industries, and the people of the Middle East.

The Russians have also shown interest in our activities and according to Pravda they have done us the doubtful honor of instituting on a national scale some of our unorthodox educational procedures.

It may be recalled that last year among other things the writer recommended that we "establish a 'pilot plant' institution founded on the basic concepts which established American professional engineering, with complete freedom to ignore any and all systems and which is dedicated to developing a process whereby the potential intellectual leaders of our on-coming generations can be adequately trained and educated in Engineering and Technology at a rate which is determined by their own capacity to develop."

Today he wishes to repeat that recommendation and to broaden it to include the physical sciences as well as engineering. Not only is the establishment of one or more of such institutions vital to our survival, but it is immediately possible and relatively inexpensive. All that is really required is complete freedom of action and a reasonable amount of money. There are enough of the required kind of faculty available who would be delighted to break with tradition and do what needs to be done, if they are given some means of assembling and of getting support for the necessary programs.

It is also recommended that, in order that we may gain an effective amount of international maturity and sophistication as rapidly as possible, our elementary and secondary schools be taken out of their provincial insular cocoons and recast on a realistic basis.

To do this, authority to determine who may enter or continue in school must be given back to the teachers—not to administrative appointees, but to the teachers themselves. Foreign languages taught as second languages must be required from kindergarten on. Genuine cultural subjects must be retained and strengthened but the "fresh-air" and "pipe" courses must be removed in order to make room for the solid work that is not now being done. Finally, the work load should be materially increased.

The state colleges and universities must be freed from having to take automatically the graduates of the high schools of the state. Entrance to any institution of higher education must be on a competitive selective basis to be effective. All general college courses must be freed from the insular approach and reoriented on a global base. Spectator sports and other similar activities must be more adequately offset by participant activities.

Organized labor must cooperate by devising a training system that will extract from the academic systems everyone who demonstrates that he is better fitted for that equally important segment of our society, the skilled and

semi-skilled citizen. A first-class machinist or butcher or welder, etc., is far more important and valuable than a second-rate graduate.

Our organized religion must do some soul-searching and come up with answers to the moral side of the problem. Telling us that we should all live as brothers and pray more or go to church more isn't adequate. Pious platitudes will not suffice in this crisis. We need a dynamic restatement of our Christian code that can be accepted by intelligent men as reasonable and workable. We need one that the bulk of Americans will live, not just practice on Sunday.

It must provide us with the spiritual and moral dynamics required for the inspiration and discipline of our individual and collective daily lives, which we need to compete successfully with the virulent atheistic ideology of the Russian.

Above all, we must break this slavish national adherence to uniformity and reestablish the basic American right to be an individual.

Congress is giving the President a large amount of money, supposedly to ensure that we catch up with the Russians. The writer contends, however, that there will be no catching up or even survival for the American way of life unless we get it through our heads that the basic elements required for survival cannot be bought with money alone.

In this deadly competition, creative intellectual capacity and moral socio-political maturity are the basic weapons required for survival. At the moment our arsenal seems badly understocked. However, the writer has an abiding faith in the American people's ability to face facts and deliver the goods. The English are not the only ones in the West who can stand up and deliver under a promise of nothing but blood, toil, tears and sweat. There is far more sinew and tough moral fiber under our bloated bureaucracy, confused behavior, seeming hypocrisy and plush uniform materialism than even our own government realizes.

When informed of the facts and the urgency, the American people can and will forge the vital weapons required to implement the only strategy open to us, namely that of survival on this earth as a moral, intellectually creative Christian nation.

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Journal of
PROFESSIONAL PRACTICE
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Note: Paper 1883 is part of the copyrighted Journal of Professional Practice, Proceedings of the American Society of Civil Engineers, Vol. 84, PP 1, December, 1958.

PROFESSIONAL EARNING AND SATISFACTION SURVEY OF CIVIL ENGINEERS[a]

Discussion by K. E. McKee

K. E. McKEE,[1] A. M. ASCE.—The Junior Activities Committee of the Kansas City Section of ASCE is to be commended for their efforts in conducting this survey. If we are to understand our profession and its problems, surveys of this type are an absolute necessity. Too often the Civil Engineer feels that his problem is unique, while it actually exists throughout the profession.

With respect to salaries, the writer feels that the committee's presentation of the data is misleading. The average of $9140 is deceptive in that a relatively small percentage of engineers receive that salary. Using the data presented 44 per cent of those responding earn less than $7000, 54 per cent less than $7500, and 75 per cent less than $10,000. The median salary, of those answering the question is between $7000 and $7500. The "average" engineer therefore, earns between $1640 and $2190 a year less than the average salary. The salary ranges tabulated are also poor since 40 per cent of the replies with salaries between $7500 and $15,000 are divided into only two classifications. Additional divisions would provide a more complete picture of the salary distribution.

It is interesting to compare the above salaries with that earned by skilled labor in the same area. A bricklayer ($3.75[2] an hour) working 40 hours a week would earn $7320 a year, excluding a two week vacation and normal holidays. A bricklayer therefore earns more than approximately 50 per cent of the members of ASCE in the Kansas City section. Under these circumstances it is not surprising that salary was found to be the weak point in resisting the threat of unionism.

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a. Proc. Paper 1486, December, 1957, by the Junior Activities Committee, Kansas City Section, ASCE.

1. Research Engr., Structural Analysis Section, Dept. of Mech. Eng. Research, Armour Research Foundation of Illinois Inst. of Technology, Chicago, Ill.
2. Engineering News-Record, Jan. 30, 1958, p. 62.

Paper 1891 December, 1958 PP 1

Journal of

PROFESSIONAL PRACTICE

Proceedings of the American Society of Civil Engineers

ABSTRACTS AND INDEXES FOR PROCEEDINGS, VOL. 84, 1958

(Proc. Paper 1891)

FOREWORD

This index has been prepared in an effort to supply a list of topic headings as a guide to material published in the Proceedings of ASCE during 1958. The abstracts included herein are presented to indicate to the reader what general information can be found in the paper in question. The author listing has been made as complete as possible and includes the names of co-authors, discussers, and committee chairmen of the several reports. Subject headings have been greatly restricted, for the sake of brevity, under three basic rules:

1. Each paper is listed under one primary heading suggested by the name of the technical divisions of the Society. No other entry is made for the paper if that one entry is considered to be sufficient.
2. A secondary listing is used if further classification is essential. In this second listing an attempt is made to place papers published in one Division's Journal also under another Division's name so that readers of the Journal of one Division can be made aware of other papers that might be of interest to them.
3. A geographic listing (by states of the United States and by foreign countries) is recognized where location is of particular importance.

References to discussers of a given paper can be found immediately under the name of the senior author in the author index. Discussion that occurred in more than one calendar year can be traced by referring to the senior author's name in successive indexes, until the closing remarks are located. If discussion is published in the same year as the paper, the listing of this discussion is made directly after the listing of the paper in the subject index. If the discussion appears in the year following the paper's publication, then the subject indexing of that discussion is made in alphabetical order under the appropriate subject heading.

Typical abbreviations used in this index are: Dsc for "discussion," Clo for "closing discussion," Rt for "report," Corr for "corrections," and Chmn for "chairman" of a committee submitting a report. All numbers refer to the number of the Proceedings Paper, no page numbers are included in this index. Immediately following the Proceedings Paper number, the letter and number

Note: Paper 1891 is part of the copyrighted Journal of Professional Practice, Proceedings of the American Society of Civil Engineers, Vol. 84, No. PP 1, December, 1958.

symbols indicate which of the several Division Journals the particular paper appeared in. By referring to the back inside cover of any Division Journal the month of issue of any Journal can be ascertained.

Items indexed are identified by months as follows:

Month	Number
January	Proc. Papers 1494 to 1527
February	1528 to 1559
March	1560 to 1579
April	1580 to 1620
May	1621 to 1657
June	1658 to 1691
July	1692 to 1724
August	1725 to 1749
September	1750 to 1789
October	1790 to 1832
November	1833 to 1858
December	1859 to 1891

Journals published during 1958 are as follows:

Month	Journals
January	Engineering Mechanics, Highway, Irrigation & Drainage, Structural, Waterways & Harbors
February	Hydraulics, Power, Sanitary Engineering, Soil Mechanics & Foundations
March	Pipeline, Structural, Waterways & Harbors
April	City Planning, Engineering Mechanics, Hydraulics, Irrigations & Drainage, Power, Sanitary Engineering, Surveying & Mapping
May	Highway, Soil Mechanics & Foundations, Structural, Waterways & Harbors
June	Air Transport, Hydraulics, Pipeline, Power, Sanitary Engineering
July	Engineering Mechanics, Sanitary Engineering, Structural, Surveying & Mapping
August	Hydraulics, Power, Soil Mechanics & Foundations
September	Irrigation & Drainage, Sanitary Engineering, Structural, Waterways & Harbors
October	Engineering Mechanics, Highway, Hydraulics, Power, Soil Mechanics & Foundations, Structural
November	Hydraulics, Sanitary Engineering, Structural, Surveying & Mapping
December	City Planning, Hydraulics, Irrigation & Drainage, Power, Professional Practice, Soil Mechanics & Foundations, Structural, Waterways & Harbors

SUBJECT INDEX

AFGHANISTAN
"Rockfill Dams: Kajakai Central Core Dam, Afghanistan" (1735PO4) by Glenn F. Sudman

AIR TRANSPORT
"Airport Approach, Runway and Taxiway Lighting Systems" (1659AT1) by C. Edward Walter, and Vincent J. Roggeveen
"The Effects of Air Pollution on Airport Visibility" (1543SA1) by William T. Ingram and Louis C. McCabe
"Ground Transportation at New York International Airport" (1623HW2) by Richard I. Strickland
"Municipal Financing of Airports" (1669AT1) by Rollin F. Agard
"Surveying for Richard I. Bong Air Force Base" (1699SU2) by Peter A. Machinis
"A Water-Borne Runway" (1658AT1) by David Williams

ANALOGS
"An Analog Computer for the Oxygen Sag Curve" (1850SA6) by Morton D. Sinkoff, C. Don Geilker and Jan G. Rennerfelt

ARCHES
"Analysis of Open-Spandrel Arches" (1564ST2) by A. F. Diwan
"Numerical Analysis of Two-Hinged Arches" (1758ST5) by Thomas D. Y. Fok and Tung Au

ATOMIC ENERGY
"Blast Loading on Structures" (1837ST7) by H. L. Murphy
"Blast Phenomena From a Nuclear Burst" (1836ST7) by Ferd E. Anderson, Jr.
"Civil Engineering Aspects of the Dresden Nuclear Power Station" (1600PO2) by Joseph E. Love, Chester S. Darrow, and Burr H. Randolph
"Civil Engineering Aspects of the Fermi Atomic Power Station" (1602PO2) by Pharo C. Burg and John G. Feldes
"General Considerations for Reactors and Related Plant Types" (1763ST5) by John F. Stolz
"Insurance Aspects of Nuclear Energy" (1599PO2) by Edward R. Lloyd
"Hydrological Aspects of Radioactive Waste Disposal" (1835SA6) by William H. Bierschenk
"Spherical Containment Shell of the Dresden Station" (1601PO2) by L. P. Zick, J. T. Dunn, and J. B. Maher

BEAMS
"Analysis of Continuous Beams by Carry-Over Moments" (1762ST5) by Jan J. Tuma
"Analysis of Finite Beams on Elastic Foundation" (1722ST4) by Denos C. Gazis
"Concrete Beams and Columns with Bundled Reinforcement" (1818ST6) by N. W. Hanson and Hans Reiffenstuhl
"Effect of Deflection on Lateral Buckling Strength" (1596EM2) by J. W. Clark and A. H. Knoll
"Elasti-Plastic Analysis of Continuous Frames and Beams" (1879ST8) by Lawrence P. Johnson, Jr., and Herbert A. Sawyer, Jr.
"On Inelastic Buckling in Steel" (1581EM2) by Geerhard Haaijer and Bruno Thurlimann
"The Location of Maximum Principal Stresses" (1629ST3) by T. Ranov and H. S. Wolko
"Matrix Analysis of Beams" (1494EM1) by Ray W. Clough
"Moments in Beams by the Method of Partial Moments" (1567ST2) by Harry Posner
"Moments In Continuous Beams On Flexible Supports" (1631ST3) by Robert A. Williamson
"Numerical Solutions for Beams on Elastic Foundations" (1562ST2) by Henry Malter
"Plastic Design of Cover Plated Continuous Beams" (1495EM1) by E. P. Popov and J. A. Willis

BRIDGES
Rt: "Deflection Limitation of Bridges: Progress Report of the Committee on Deflection Limitations of Bridges" (1633ST3) C. P. Siess, Chmn
"Design Features of Lower Deck of George Washington Bridge" (1632ST3) by Irvine P. Gould
"The Design of the Main Towers of the Mackinac Bridge" (1565ST2) by Kuang-Han Chu
"Golden Gate Bridge Vibration Studies" (1817ST6) by George S. Vincent
Rt. "Highway and Bridge Surveys: Introduction to Bridge Surveys and Reconnaissance Survey" Progress Report of the Committee on Highway and Bridge Surveys (1713SU2) Milton O. Schmidt, Chmn.
"Highway and Bridge Surveys: Preliminary Bridge Surveys. Progress Report of the Committee on Highway and Bridge Surveys" (1842SU3) Milton O. Schmidt, Chmn.
Rt: "Highway and Bridge Surveys: Reconnaissance, Progress Report of the Committee on Highway and Bridge Surveys" (1593SU1) Milton O. Schmidt, Chmn.
"Inspection and Tests of Welding of Highway Bridges" (1866ST8) by John L. Beaton
"Numerical Solutions for Interconnected Bridge Girders" (1815ST6) by Henry Malter
"Precise Surveys for Mackinac Bridge" (1716SU2) by R. M. Boynton
"Railroad Bridge Alterations, Calumet-Sag Project" (1641WW3) by George W. Svoboda

BURMA
"Irrawaddy River System of Burma" (1766WW4) by Henry R. Norman

CALIFORNIA
"The Haas Hydroelectric Power Project" (1529PO1) by J. Barry Cooke
"Design and Performance of Vermilion Dam, California" (1728SM3) by K. Terzaghi and T. M. Leps

1879. Elasti-Plastic Analysis of Continuous Frames and Beams, by Lawrence P. Johnson, Jr., and Herbert A. Sawyer, Jr. (ST) An analytical solution considering both elastic and plastic flexural deformations is presented for continuous beams and frames. The method has limitations characteristic of limit design methods except that it determines strength as defined by the moment-curvature relationship as well as an ultimate moment, and allows ready determination of deflections.

1880. Discussion of Proceedings Paper 1197, 1662. (HY) J. Bogardi corrections to 1197. Howard M. Turner on 1662.

1881. Discussion of Proceedings Paper 1645, 1648, 1649, 1654, 1655. (SM) R. G. Ahlvin, D. Hugh Trollope on 1645 A. A. Eremin on 1648. A. A. Eremin on 1649. D. P. Krynine, Dean R. Freitag on 1654. J. MacNeil Turnbull on 1655.

1882. Discussion of Proceedings Paper 1638, 1708, 1709, 1710, 1712, (ST) B. R. Cooke on 1638. Arthur N. Gilbert on 1708. Arthur N. Gilbert on 1709. Arthur N. Gilbert on 1710. Arthur N. Gilbert, Louis Balog on 1712.

1883. Discussion of Proceedings Paper 1486. (PP) K. E. McKee on 1486.

1884. Discussion of Proceedings Paper 1514, 1568, 1571. (WW) Louis H. Foote closure to 1514. C. L. Bretschneider corrections to 1568. J. E. Chappelear on 1568. Basil W. Wilson on 1571.

1885. Discussion of Proceedings Paper 1620. (CP) Nathan Cherniack, William H. Claire, Joseph Horowitz on 1620. Sergei N. Grimm Closure to 1620.

1886. Las Morochas Gas Turbine Power Plant, by A. J. Michael. (PO) This paper presents civil engineering aspects of gas turbine power plants which are different from the more conventional type of thermal power plant.

1887. Civil Engineering Features of TVA Steam Electric Stations, by George P. Palo, Walter F. Emmons, and Nathan E. Way. (PO) Since 1949 the TVA has built seven large steam electric stations. This paper presents features which are of interest in the design of steam plants.

1888. Ocean Cooling Water System for 800 MW Power Station, by Robert H. Weight. (PO) The use of ocean water for cooling must provide for corrosion effects and control of fish and marine growth. This paper describes model studies assuring economical control and handling of water quantities used, with consideration to earthquake and subsidence.

1889. Water Supply to Thermal Power Plants, by E. J. Stankiewicz. (PO) This paper examines water quantities required, sources, circulating water systems and uses, and reviews the water supply systems for several power stations.

1890. Experiments on Self-Aerated Flow in Open Channels, by Lorenz G. Straub and Alvin G. Anderson. (HY) Measurements of air-concentration distribution in high velocity open-channel flows indicate that air content can be related to the flow characteristics and can be described by turbulence concepts.

1891. Abstracts and Index to Proceedings, Volume 84 (1958), by the Board of Direction. (BD) A list of abstracts and a subject and author index have been prepared for all Proceedings Papers published in 1958; the numbers covered are 1494 to 1890. The subject headings used were taken from the names of the technical divisions of the Society; other headings were added when deemed necessary. By use of the author index, it is possible to trace all the discussion that a paper has received.

CALIFORNIA
"Rockfill Dams: Cherry Valley Central Core Dam" (1733PO4) by H. E. Lloyd, O. L. Moore and W. F. Getts
"Rockfill Dams: Salt Springs and Lower Bear River Concrete Dams" (1737PO4) by I. C. Steele and J. B. Cooke
"Rockfill Dams: Wishon and Courtright Concrete Face Dams" (1746PO4) by J. Barry Cooke
"Sewage Disposal in Santa Monica Bay, California" (1534SA1) by C. G. Gunnerson

CANADA
"Road Development in Ontario" (1524HW1) by W. J. Fulton
"Rockfill Dams: The Bersimis Sloping Core Dams" (1740PO4) by F. W. Patterson and D. H. MacDonald
"Underground Power Plants in Canada (1670PO3) by A. W. F. McQueen, C. N. Simpson and I. W. McCaig

CITY PLANNING
Rt: "City Planning Education for the Civil Engineer: Progress Report of the Committee on Education" (1877CP2) Lloyd Rader, Chmn.
"Integrated Planning of Highways and City Streets" (1628HW2) by Guy Kelcey and George Leland
"Organization of Metropolitan Districts" (1680SA3) by Langdon Pearse
"Some Aspects of Urban Planning" (1620CP1) by Sergei N. Grimm

COLORADO
"Montgomery Dam--Rock Fill with Asphaltic Concrete Deck" (1556PO1) by F. W. Scheidenhelm, John B. Snethlage and Arthur N. Vanderlip

COLUMNS
"Approximate Buckling Loads of Open Columns" (1793EM4) by Yu-kweng M. Lin
"Biaxially Loaded Reinforced Concrete Columns" (1865ST8) by Kuang-Han Chu and Algis Parbacius
"Concrete Beams and Columns with Bundled Reinforcement" (1818ST6) by N. W. Hanson and Hans Reiffenstuhl
"Design of Long Reinforced Concrete Columns" (1694ST4) by Bengt Broms and I. M. Viest
"Eccentrically-Loaded, Hinged Steel Columns" (1792EM4) by R. E. Mason, G. P. Fisher and Geo. Winter (1792EM4)
"Lateral Bracing of Columns and Beams" (1561ST2) by George Winter
"Lateral Load Analysis of Two-Column Bents" (1638ST3) by John E. Goldberg
"Ultimate Strength Analysis of Long Restrained Reinforced Concrete Columns" (1635ST3) by Bengt Broms and I. M. Viest

COMPUTERS
"An Analog Computer for the Oxygen Sag Curve" (1850SA6) by Morton D. Sinkoff, C. Don Geilker and Jan G. Rennerfelt
"Columbia Basin Streamflow Routing by Computer" (1874WW5) by David M. Rockwood
"Computation of the Stability of Slopes" (1824SM4) by Otto H. Meyer
"Digital Computation for Stiffness Matrix" (1814ST6) by J. S. Archer
"Digital Computers Applied to Pipeline Design" (1575PL1) by Harold E. Thomas
"Digital Computers for Pipeline Network Analysis" (1608SA2) by Quintin B. Graves and Don Branscome
"High-Speed Computer Applied to Bridge Impact" (1759ST5) by Charles T. G. Looney
"Hydraulic Problem Solution on Electronic Computers" (1515WW1) by Edward A. Lawler and Frank U. Druml
"Mechanical Analogs Aid Graphical Flood Routing" (1585HY2) by Max A. Kohler
"Rigid Frame Analysis With The Aid of Digital Computers" (1634ST3) by E. Czerniak
"Use of Modern Computer in Structural Analysis" (1636ST3) by Ray W. Clough
"Water Distribution Design and the McIlroy Network Analyzer" (1588HY2) by M. B. McPherson and J. V. Radziul
"Water Distribution Problems Solved by Network Calculators" (1577PL1) by L. M. Haupt

CONCRETE
"Incremental Compression Test for Cement Research" (1604EM2) by A. Hrennikoff
"A Method of Design of Reinforced Concrete Sections" (1509ST1) by Panagiotis D. Moliotis
"Reinforcement in Continuous Concrete Pavements" (1799HW3) by Vedat A. Yerlici
"Review of Limit Design for Structural Concrete" (1878ST8) by C. W. Yu and Eivind Hognestad
"The Structural Properties of Magnetite Concrete" (1511ST1) by Jerome M. Raphael
Rt: "Tentative Recommendations for Prestressed Concrete: Report of the Joint ACI-ASCE Committee on Prestressed Reinforced Concrete" (1519ST1) Thor Germundsson, Chmn
"Tests of Concrete Pavements on Gravel Subbases" (1800HW3) by L. D. Childs and J. W. Kapernick
"Thermal Consideration in the Design of Concrete Shields" (1755ST5) by Harold S. Davis
"Ultimate Strength Analysis of Long Hinged Reinforced Concrete Columns" (1510ST1) by Bengt Broms and I. M. Viest

CONNECTICUT
"Connecticut Highways and the 1955 Floods" (1621HW2) by Newman E. Argraves

CONSERVATION
"The Engineer and Worldwide Conservation of Soil and Water" (1775IR3) by Orson W. Israelsen

CONSTRUCTION
"Glued Laminated Wood Construction in Europe" (1840ST7) by M. L. Selbo and A. C. Knauss
"Waterfront Structure Design For Varying Conditions" (1639WW3) by William C. Stevens and John S. Wilson

A survey by NSPE(5) of income and salary of registered engineers throughout the country in 1956 showed that teaching ranked below executive and administrative work, below sales, and below research and development but ahead of design, production, and the supervision of construction. The salaries of registered engineering professors were near the national median.

The aforementioned CDEF of ASEE conducted a survey and issued a report in 1957 that tabulated the average incomes of engineering teachers of various ranks in state universities and in private schools for 1956. This report was especially significant because it gave the outside remuneration of teaching personnel as well as their academic salaries. Table 1, abstracted from page 5 of that report, shows the mean annual incomes and teaching salaries of all engineering teachers in both public and private institutions.

Table 1. Mean Annual Salaries and Incomes of Engineering Teachers (from ASEE Report, 1957)

Rank	Basic Teaching Salary*	Outside Income	Total Income
Instructor	$ 4,258	$ 1,094	$ 5,352
Asst. Prof.	5,384	1,878	7,262
Lecturer	5,422	2,144	7,566
Assoc. Prof.	6,554	2,293	8,847
Professor	8,538	3,113	11,651
Dept. Head	9,320	2,218	11,538
Dean	11,211	2,496	13,707
Mean for all Respondents	6,634	2,228	8,862

*These figures do not take into account variations among schools in the number of months of teaching.

Basic teaching salaries were slightly higher than the mean in private institutions and slightly lower in state universities; but the differences were $\pm 5\%$ or less. Outside incomes, however, were considerably higher for teachers in private than in public schools, especially in the higher ranks. These differences are probably attributable to the fact that most private institutions are located in large metropolitan areas where consulting opportunities are frequent, whereas many state universities are situated in small communities. Moreover, state universities may be more restrictive with respect to consulting.

It is interesting to note that the average total income of full professors was slightly higher than that of department heads, owing to more outside remuneration. It is also significant to express outside income as a percentage of the academic salary, as shown in Table 2. These percentages reveal that the average engineering teacher may expect to earn from outside sources an amount equal to about one-third of his academic salary. Professors and associate professors in private schools generally receive outside incomes equal to about half of their regular salaries.

Not all of this outside income comes from consulting work and other activities during the academic year. Much of it represents remuneration for summer work when school salaries are stopped. The CDEF report for ASEE contains a tabulation of true monthly teaching salaries by rank, i.e. the annual salary divided by the number of months worked. It also compares "annualized" teaching salaries (monthly salaries times 12) with total incomes, the difference representing outside income in excess of a 12-month salary. On this basis, the mean outside income as a percentage of academic salary for all respondents in public universities drops from the 27.9% in Table 2 to a mere 3.3%. For private schools the corresponding drop is from 45.9 to 17.2%.

From the foregoing surveys and statistics it is apparent that the earnings of the average college engineering professor are as high as the median engineer in his age bracket, or perhaps slightly better when outside income is considered. On that basis, should we pity the poor professors publicly and thereby scare off the best young engineers who are needed so badly now to build up our inadequate faculties? Certainly not. We should encourage the best of our present crop to remain as seed for propagation of expanded and improved academic staffs!!

Table 2. Outside Income as a Percentage of Academic Salary (data from ASEE Report, 1957)

Rank	Public	Private	Total
Instructor	24.7	28.3	25.7
Asst. Prof.	30.2	43.3	34.9
Lecturer	39.5	39.8	39.6
Assoc. Prof.	28.9	53.5	34.9
Professor	29.2	52.1	36.5
Dept. Head	18.8	36.9	23.8
Dean	15.0	37.0	22.2
Mean for all Respondents	27.9	45.9	33.7

Additional Financial Incentives

While wailing and pity are scarcely justified by the statistics of average income, should we expect our best seed for future engineering faculties to be content with median salaries? These are the young men at the top of their classes scholastically, the men most likely to succeed in private enterprise or government organizations, the men who should be in the upper quartile or upper decentile of the profession. To ask them to sacrifice earnings for two to four years of graduate study and then remain at the median salary level throughout their lives is certainly unjust and unrealistic. If we expect to entice our best seed for the propagation of future crops, we must make a career in teaching as financially attractive as the better-paid positions in administration, management, sales, and consulting.

How can the total incomes of engineering faculties by improved? The answer that comes first to mind is to increase academic salaries; but it

involves many corollary problems. Private colleges are non-profit institutions that operate largely on the income from restricted endowments. It is becoming increasingly more difficult to raise large endowments in the face of high taxation and limitations on donations. The portion of income derived from tuition can be increased and it should be, in many instances; but tuition provides only a small part of the total operating income of most private engineering schools. High tuitions place private colleges at a slight disadvantage with respect to state universities when competing for the best brains.

The budgets of public universities, on the other hand, are dependent largely upon annual appropriations by the state legislatures -- political bodies sensitive to many pressure groups interested in keeping taxes at a minimum. Furthermore, salaries in public schools are based almost solely upon rank and longevity, regardless of specialty, rather than upon supply and demand. Thus, a professor of history makes as much as a professor of engineering despite the fact that history teachers are plentiful and seldom subject to proselytism by industry.

Irrespective of the roadblocks, pressure should be maintained for increases of engineering faculty salaries. Individual members of ASCE, and local sections as collective bodies, can assist such pressure by urging state legislatures to raise salaries in public universities, which, in turn, will be reflected in private colleges. Our more affluent colleagues in ASCE can help by contributing to the endowments, scholarships, and development funds of private institutions. The long-term trend of such actions will be favorable but they will not solve the immediate problem.

What, then, can be done in the next few years? The best immediate solution is to help engineering teachers augment their outside incomes. The opportunities available for extra-curricular work vary with geographic location, the specialty of the professor, and his aggressiveness. Some professors are quite reluctant to seek outside work. Indeed, many academic personnel, living in ivory towers, may be likened to "Engine-Charlie" Wilson's well-known kennel dogs.

To help engineering professors improve their outside income, it would be well to consider the present sources of such funds. Consulting represents the highest and most remunerative form of outside work. Most schools allow a faculty member to spend an average of one day a week in professional consultation. Here it is best for professors to work for or through established consulting engineers and not in competition with them. In the past, some professors have entered into the practice of engineering, to the extent of preparing plans and specifications for construction, but such competition should be discouraged by the ASCE, the consultants, and the colleges alike. The professor can provide a distinct and unique service as a consultant's consultant, or an advisory consultant. In such a capacity, it is best that he be placed on a regular monthly retainer rather than on a haphazard per-diem basis. He can serve effectively as an adviser to manufacturers and producing industries, as well as to practicing engineers.

Another source of outside income is the preparation, editing, and review of textbooks. Several engineering texts have been phenomenally successful and remunerative, such as French's "Engineering Drawing" or Johnson's "Materials of Construction." Others have brought in tidy and steady sums, especially when the books were revised frequently. In general, however, textbook writing is a labor of love, with little promise of sizeable financial return. Some professors prefer steady service as an editor or reviewer for a technical magazine or publishing firm.

A few positions with financial remuneration are available as secretary or treasurer of honor fraternities and local sections of engineering societies. Again, however, the return is not commensurate with the time and effort involved.

Outstanding professors are called upon frequently to serve on advisory boards for federal, state, and local agencies. Most of these positions pay $100 a day or even more. There are some public officials, however, who expect professors to donate their time and efforts on such boards as a public service. This attitude should be corrected immediately in the minds of all concerned.

Government, industry, and private engineering firms should take the initiative to employ more engineering professors in various advisory capacities. Everyone will benefit from such action. The employing agency will benefit, for it will have access to topflight brains trained in the latest theory and knowledge. In comparison with the expected returns the cost will be relatively minor, especially with no overhead, retirement, social security, and vacation pay involved. Furthermore, the employing agency will have contact through the professor with his best students as prospective future employees. In many ways, the employing agency gets more from part-time employment of faculty members than the other parties involved.

The professor will benefit in several ways. The added income will enable him to remain in the academic role that he has chosen as his life's work. Also, it will bring him in contact with realities in the practice of engineering to supplement his theoretical approach. The student will benefit from the better-rounded experience and outlook of his professors and from easier contacts with prospective employers. Finally, the school will benefit if, by these arrangements, it can attract and hold better faculties.

SUMMARY

It has been the intent of this dissertation to point out the need for expanded and improved faculties of engineering, to explore reasons for the current shortage of competent professors, to examine the salaries and other income of engineering professors, and to analyze methods for retaining outstanding young engineers in the academic community. To summarize, it is recommended that each segment of the engineering profession cooperate to overcome the shortage of competent engineering faculties by the following actions:

1. Professors should urge their best senior students to go to graduate school and to prepare themselves for a teaching career. The best graduate students should be encouraged to continue for doctor's degrees.

2. Students in the upper quarter of the class should think seriously about teaching as a career. It has many advantages. Anyone who has the aptitude and desire to teach need not be discouraged by the financial returns, especially if he is willing to do outside work.

3. Consulting engineers should each add a few professors to their technical staffs and hold them there by equitable monthly retainers. The consulting engineers, as well as the professors, students, and colleges, should benefit greatly from this arrangement.

4. Government agencies, on federal, state, and local levels should retain more professors on an advisory consulting basis. Where shortsighted civil-service regulations and closed-door protectionist policies prevent such consulting, they should be amended.

5. Industries, equipment companies, trade associations, and contractors could benefit greatly from stimulation provided by part-time employment of professors. Again, monthly retainer fees are indicated to assure a continuity of effort and allegiance.

6. National societies such as ASCE can help by acting as clearing houses for professors and potential part-time employers who have difficulty making contact. Engineering teachers in rural areas lack the opportunities for contact with prospective firms. Yet, many isolated professors can serve in several capacities — as long-range advisors to equipment manufacturers or to trade associations, as editorial assistants or authors, as officers of national or local technical societies, and in many other ways. ASCE can also assist by local section action to persuade state legislatures to raise engineering salaries in public universities.

CONCLUSION

The shortage of competent engineering faculties, already serious and bound soon to become acute, will not be overcome by self-pity and public wailing over the poor economic plight of teachers. Indeed, such action will aggravate the shortage by driving away the best young graduates who should be returning to the academic life as seed for future crops. Surveys and statistics do not support contentions of poverty nor justify public pity, for teaching in an engineering school can be a rewarding life. Yet, financial inducements should be improved if our best seed is to be retained. To solve the shortage of competent engineering faculties, all segments of the profession can pitch in to assure that salaries are raised and that the outside incomes of professors are sufficient to make teaching attractive to our best young brains.

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IMPORTANCE OF EMPHASIS IN CIVIL ENGINEERING EDUCATION

L. E. Grinter[1]

(Proc. Paper 1871)

The disconcerting facts presented by the Task Committee on Professional Education* were sensed by the ASEE Committee on Evaluation of Engineering Education several years earlier, but proof was lacking. A great service has been performed by the Task Committee in bringing to light the following attitudes which go a long way toward explaining why the profession of civil engineering, relatively speaking, has been losing its attraction to young men. Junior grade civil engineers voted 3 to 1 that the public considers other branches of the profession more important than civil engineering; and on a 3 to 2 basis they agreed with that opinion. In confirmation of this view those who are best able to compare and contrast the differences in educational values in the curricula of the several major branches of engineering, i.e., the deans of engineering schools, voted in a ratio of 10 to 1 that civil engineering is the "least promising" over the "most promising" branch for the future of students.

It is also significant to note that in a ratio of 11 to 1 the deans of engineering voted for electrical over civil as the most promising field of study for the future of students. Even if the votes of deans who preferred not to commit themselves are divided equally between the branches of engineering, electrical still outpoints civil by 3 to 1. The writer believes that deans weigh two main factors in arriving at such a decision. One is a factor partly but not entirely external to education, that is, the comparative volumes of research and development work leading to new engineering tasks. The other factor encompasses the educational values inherent in curriculum and teaching that prepare students to assume responsibility for new tasks. The deans obviously believe that these factors combine favorably in electrical engineering and are not sufficiently present in the profession and the education of civil engineers. Even if this is true today, it need not be true tomorrow, but the only place to change it is in the education of future civil engineers.

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* Civil Engineering, February, 1958, p. 111.

Breadth of Useful Knowledge

After recognizing the serious implications inherent in the relative lack of enthusiasm expressed for the future of civil engineering as a profession for young men, the Task Committee analyzed the varied demands for knowledge that come upon civil engineers. These demands go beyond engineering science, analysis, and design to include a knowledge of construction art, financial and legal planning, socio-political relationships and the development of judgment permitting the civil engineer to operate "beyond the well documented but relatively limited areas of systematized knowledge." This is the survey approach used by most analysts of education. Surprisingly enough, such a survey of job requirements usually ends by justifying almost every existing curriculum. If we apply the same type of survey to life adjustment problems of high school students, the results provide justification for a study of driver education, personality development, family life, and applied recreation while substantiating less effectively the critical need for more study of mathematics, English, science, languages, and history. Even in college we sometimes try to teach judgment before knowledge has been acquired through study of hard-core academic subjects. The loss, which is not so obvious, is that the academic courses provide tools for future thinking about the most significant problems of life, particularly the new problems encountered in a rapidly changing world. It is the more scientific courses and the humanistic courses in the civil engineering curriculum that perform this service for the professional engineer.

Transferability of Knowledge

It is enlightening to consider civil engineering education from the viewpoint of its transferability to widely varying jobs. There is really no unified concept covering the "art of civil engineering." There was an art in railway construction which civil engineers studied long after railroads ceased to be built and even after the railroads ceased to employ appreciable numbers of civil engineering graduates. Nearly all present civil engineers studied highway construction and paving practices, but only a small fraction have transferred the art learned into job application. In such courses it is only the small content of engineering science and the rather limited practice in using engineering science in analysis and design of components and systems that is transferable on a reasonably broad basis. In the hydraulic field a course such as open channel flow may have considerably more transferability to industrial and defense applications as well as public works employment, and again this is due to its relatively high content of engineering science, analysis and design. Whatever content of such a course is devoted to means of hydraulic protection, such as riprapping or sandbagging, and other practical arts is essentially nontransferable.

Obsolescence Factors

There is another characteristic about the study of art or practice that should be discouraging to the educator. All such knowledge suffers from an extremely high degree of obsolescence with time. The art of concrete construction has changed with scientific understanding of the setting process,

with change in winter protection procedures, with air entrainment, with water removal techniques, with vibration, with reusable forms, with precast elements, with lift slabs, with prestress, with fast moving rubber tired vehicles, etc. No ten-year period has seen less than a near revolution in construction procedures while the art or practice taught the student via the textbook is usually more than a decade old.

When the factor representing change in the art, which might safely be given a probability of obsolescence factor of 50 per cent per decade, is combined with the probability factor that the student will enter the corresponding branch of the profession, which usually represents less than one-quarter of the civil engineering area, the over-all probability of a given student using art or practice taught in a given course may be expressed crudely as the product of a group of factors such as

$$0.5 \times 0.7 \times 0.25 \times 0.6 = 0.05, \text{ or one student in } 20$$

The first factor allows for the average obsolescence of the textbook and of the teacher's contact with the art; the second factor allows time for the student to graduate and pass the first stage of apprenticeship; the third factor represents a rough division of the civil engineering area into structural, transportation, hydraulic, sanitary, soils or foundations; the last factor allows for overlapping subdivisions such as steel, wood, and concrete within the structural area. The reader may change any factor to suit himself without changing the conclusion as to the small probability of direct usefulness in professional life of art or practice learned in college. This crude analysis may be summarized by the generalization that in each class in engineering perhaps one or two students may make direct use of the specialized art, practice, technique or rules of procedure covered by the textbook or expounded by the teacher. All the other students in the class must benefit first from the content of study material having a higher degree of transferability, such as engineering science, and second from training in the engineering methodology of analysis and design which is relatively transferable to other fields and does not require extensive study of art or practice.

Art Versus Academics

The type of probability analysis carried out above has at least the merit that it challenges us to set a use value on each bit of material introduced into the engineering curriculum. Why study English? It is nearly 100 per cent transferable to every engineering job including other college study, and it has no significant obsolescence factor. Mathematics has a high transferability to all positions in engineering analysis and design without appreciable obsolescence. What about engineering drawing? Taught as technique, drafting has a low transferability of use, but if taught as graphical language, it becomes an essential tool of every engineer. Where teachers understand this distinction the course has undergone radical changes. It is equally true that an analysis of many civil engineering courses from this viewpoint would result in rather extensive revisions. It is even possible that students are quite aware of this need for revision of courses and that their lack of enthusiasm for civil engineering curricula as they now exist was transmitted indirectly through replies to the questionnaire of the Task Committee.

A strong argument that the teaching of art must give way to the teaching of

more fundamental scientific and humanistic studies for civil engineers is found in the first of the recommended procedures of the Task Committee for strengthening civil engineering education.

> "1. Recognize and make it clear to others that professional training is a continuing process in which experience is gained and judgment is strengthened and matured by practice, based on the fundamental scientific training supplied by the colleges. A four- or even a five-year college program can give only the general educational and the technical basis for professional training. The internship and the learning-by-doing must come from association with practicing engineers. The supervising engineer must accept his responsibility for the development of the young engineers under his direction. Demands from industry or consulting firms that engineers be thoroughly trained as technical aides when they report for their first jobs are impossible to meet without sacrificing other vital aspects of their education in professional responsibilities. Industry, as well as the practicing engineer, has an obligation to help the graduate obtain the balance of his professional training."

Taking Part in New Developments

Finally, we may look into the matter of glamour or publicity attached to the various fields of engineering to locate an additional factor that makes civil engineering less attractive to students than formerly. Why is the study of engineering a thrilling experience to so many young men? Hardly a paper is printed or a magazine distributed without an article on science and engineering as the background of the new way of life. But civil engineers should notice that the two words, science and engineering, are closely associated in the public press and hence in the public mind. Taken together over a decade and a half science and engineering have created a new world for man to live in. Which engineering curricula are closest to science? Electrical and aeronautical engineering use mathematics freely and emphasize their close relationships to physics. Each of these engineering curricula shows four times the percentage increase in student registrations found in civil engineering according to the Task Committee's report.

The attitude of civil engineering faculties, with important and notable exceptions, has been to require the minimum mathematics, physics, and chemistry permitted in any engineering curriculum. Thus civil engineers have been less prepared academically to work with scientists or to take part in new developments. Perhaps we have lost sight of the common observation that the greatest need for engineers is always on the frontiers of technology. Successively, we have passed the frontiers of technology in several areas of civil engineering. Techniques become standardized, specifications control design, and the result is less actual need for engineers, more use of technicians, and less attraction as an area of engineering employment.

The process of downgrading engineering employment, just explained, will become self-generating if civil engineering education finally should accept the theory that its objective is to prepare engineers for standardized practical work rather than employment on the frontiers of technology. Only engineers with strong scientific knowledge can be expected to create new frontiers within the area of civil engineering. Such engineers in the past have often come

from Europe and have then created new frontiers of civil engineering in the United States. We think immediately of Timoshenko, Bakhmeteff, Terzaghi, and others. Such engineers with strong backgrounds in mathematics and science, far beyond the requirements of a civil engineering curriculum in this country, were able to create new frontiers in civil engineering. It may not be happenstance that cylindrical shells, prestressed concrete, and thin shell paraboloid roofs were developed more rapidly outside than inside the U. S. A.

Reversing a Negative Cycle

When a downward self-generating cycle develops through neglect it can only be changed by rather direct action. Such action in civil engineering education might be achieved by a decision to hire scientifically trained teachers whether they be civil engineers, other engineers, physicists, or mathematicians until something of a balance between interest in civil engineering practice and interest in pushing back the frontiers of knowledge has been restored. This possibility is something of a break with tradition and therefore seems rather remote unless it should receive the support of the profession.

In terms of curriculum the changes needed can be indicated by changes in the Task Committee's Table 1 entitled "Suggested Curriculum for Undergraduate Civil Engineering." The several subdivisions will appear in nearly all civil engineering curricula. However, the relative emphasis upon these divisions is a more significant matter. This factor has been added by the writer. It was necessary to separate engineering art and design in order to indicate relative emphases. Also, since ROTC must appear somewhere it was added to Item III to which it is somewhat related as are the applied aspects of human relations taught in industrial engineering or in a department of business administration.

Reports of Curricula Changes Over the Past Five Years

Recently the writer was asked by the American Society for Engineering Education to review the changes of all engineering curricula in relation to the change in demands upon engineering graduates that are being produced by rapid developments in science and technology. Reports upon curricular changes over the past four or five years were obtained from more than one-half of the engineering colleges. This survey led to the accumulation of information summarized in Tables II and III. From Table II it becomes clear that engineering schools generally are increasing the required study of mathematics and physics for many engineers. In fact, as shown by the final column of Table II, engineering colleges, on the average, have strengthened at least one area of science background for engineers. Of course, there is no indication here as to the relative changes in civil engineering and other branches of engineering study.

In Table III we have summarized the changes reported by the deans with respect to the content of courses taught in the engineering colleges. Without going into detail, it is clear from Table III that the courses in the engineering science areas of mechanics, thermodynamics, heat transfer, fluid flow, electric currents and fields and the basic study of engineering materials are being increased somewhat in credit hours at the expense of courses in engineering practice or art and of other technical courses including ROTC. It is

TABLE I

COMPARATIVE CURRICULA FOR UNDERGRADUATE CIVIL ENGINEERING

	"A" Compromise curriculum with lack of emphasis. Typical of many present offerings.	"B" Increased emphasis on fundamentals. Reasonable achievement for the near future.	"C" Strongly fundamental curriculum. To put more Civil Eng'rs on frontiers of technology.
I. General Education (History, literature, sociology, philosophy, political science, basic economics)	20%	20%	20%
II. Means and Arts in Communication			
III. Applied Aspects of Economics, Finance, Law, Human Relations, and ROTC credit		small	none in 4 years
IV. Basic Science (including mathematics)	20%	25%	25%
V. Engineering Science	20%	25%	30%
VI. Engineering Art	20%	10%	small
VII. Engineering Design	20%	15%	15%
VIII. Elective Flexibility (outside of civil engineering)	small	5%	10%

TABLE II. CHANGES IN SCIENCE CONTENT OF ENGINEERING CURRICULA

Characteristics of the Engineering Colleges Reporting	CHANGES REPORTED IN MATHEMATICS CONTENT				CHANGES IN CHEMISTRY		CHANGES IN PHYSICS SCIENCE CONTENT		
	Diff. Equations Added for All Engineers	Diff. Equations Added for Some Engineers	Required Mathematics Strengthened	Required Mathematics Under Study	Chemistry Strengthened in Credit or Content	Chemistry Requirement Under Study	Required Physics Credit Increased	Physics Requirement Under Study	Science Content Added in One Area
Colleges that awarded Ph. D. degrees in 1952-55 (45 reporting)	8%	26%	49%	18%	11%	16%	40%	22%	134%
Colleges that awarded Master's degrees in 1954-55 (35 reporting)	11%	28%	34%	6%	11%	11%	37%	9%	121%
Colleges that awarded only first degrees in engineering in 1954-55 (26 reporting)	4%	19%	54%	15%	12%	4%	35%	4%	123%

TABLE III. ENGINEERING CURRICULAR CHANGES OTHER THAN SCIENCE

Characteristics of the Engineering Colleges Reporting	CHANGES REPORTED IN ENGINEERING COURSES OF ALL TYPES						HUMANISTIC AND SOCIAL SCIENCE SEQUENCE
	Required or Elective Courses in Engineering Science Increased	Required Courses Revised to Increase Content of Engineering Science	Engineering Analysis and Design Strengthened	Engineering Science, Analysis or Design Strengthened (Total of 3 previous columns)	Courses in Engineering Practice or Art or Other Technical courses Including ROTC Reduced or Eliminated	Engineering Curricula now Under Study	Required Credit Increased or Electives Provided
Colleges that awarded Ph. D. degrees in 1952-55 (45 reporting)	40%	29%	18%	87%	87%	58%	60%
Colleges that awarded Master's degrees in 1954-55 (35 reporting)	20%	31%	17%	69%	83%	54%	66%
Colleges that awarded only first degrees in engineering in 1954-55 (26 reporting)	12%	23%	19%	54%	65%	46%	58%

also true that there has been a noticeable movement to strengthen the content of courses in engineering analysis and design. Perhaps a more significant fact is that over fifty per cent of the engineering curricula are reported to still be under study despite the recorded changes of the past few years.

Doubtless the most startling trend brought to light by this survey is reported in the final column of Table III. Over 60 per cent of the institutions reporting indicated an increase in required credit hours of humanistic study in their curricula. One recalls that the Hammond Committee of 1946 urged the colleges to adopt a minimum figure of 20 per cent of each engineering curriculum as the minimum content of humanistic and social science study. The colleges gave only lip service to this recommendation immediately after World War II in that they commonly included such technical non-engineering subjects as industrial management, English grammar, applied economics, accounting, personnel administration and ROTC as a part of the social science electives. Since the re-emphasis upon humanistic study by the Report on Evaluation of Engineering Education in 1955, a major movement to broaden the education of engineers in the humanistic and social science areas has taken place. The fact that one of the most distinguished institutes of technology reports that "the humanistic-social study requirement remains at 22 per cent of the total engineering program, which is essentially the same as it has been for the past 35 years" is evidence that this trend need not weaken the technical capacity of engineering graduates.

Quotations Regarding Changes in Civil Engineering Curricula

(Taken from reports prepared by Engineering Deans)

The following quotations should give some indication of the direction in which civil engineering curricula have been evolving over the past few years. The reports on specific changes in civil engineering curricula were somewhat less extensive than for some other areas of engineering study. However, the trends were in the same direction of increased scientific and humanistic content. In particular, there is an obvious trend to reduce the credit hours allotted to courses that emphasize the art of practice and of routine computations.

"First of all in 1957 the entrance requirements were increased so as to include mathematics through analytic geometry."

"Trigonometry was taken out and made a high school prerequisite and replaced by another (advanced) 3-credit course in mathematics."

"Differential equations is a requirement for graduation in all engineering curricula. This was made possible by requiring trigonometry as an absolute entrance requirement."

"Calculus course work for civil and industrial engineering (was) increased by 20 per cent; now (it is the) same as for electrical and mechanical."

"Our Civil Engineering Department has thrown out several arts type courses, has increased its mathematics content to that required in all other engineering curricula, namely, through differential equations, and has quantitatively improved a number of its courses. This department is preparing for another curriculum change."

"Civil, industrial, and mechanical engineering have each added a course in differential equations to their requirements at the expense of engineering courses (total hours required were not increased.)"

"Civil engineering students go through ordinary differential equations for a total of 17.25 semester hours."

"The total credit hours in mathematics was increased from 18 to 21."

"During the last few years advanced calculus has been made a requirement in chemical engineering and civil engineering."

"Statistics will probably be offered to all students because our faculty believes that few experiments can be performed properly without the use of statistics."

"Civil engineering dropped nine courses and added nine courses. One of the latter was atomic physics."

"Every engineering student is required to take four semesters of physics. This is twice the physics previously required."

"All curricula have a course in nuclear physics, not previously required."

"Credits assigned to basic physics courses were increased from twelve to fifteen."

"Humanities have been increased from approximately 20 per cent to 26 per cent."

"Over 25 per cent of each engineering curriculum is devoted to elective, humanistic-social studies."

"The civil engineering program has been reorganized and several of the more applied courses have been dropped in favor of devoting more time to basic engineering science courses. A one-year elective course in the humanities has been added to this curriculum."

"Civil engineering dropped engineering drawing as a requirement. Structural drafting (was) dropped as a requirement but (is) recommended as an elective. Engineering materials (was) dropped and replaced by the chemistry of engineering materials. Humanities electives (were) changed from 3 to 6 required units."

"The Civil Engineering Department has dropped curves and earthwork as a course required for graduation and much of this material will be incorporated in the second course in plane surveying. This will reduce the time spent on plane surveying from 10 to 7 hours."

"The civil engineering curriculum has reduced emphasis on surveying, increased emphasis on the engineering sciences and included in the senior year a two semester approved technical elective as a senior project, preferably, or a sequence of two courses aimed to provide depth in selected fields."

"Civil Engineering - These curriculum changes have slightly increased emphasis on basic and engineering sciences, a substantial increase in humanistic-social studies, and little change in engineering analysis and design and in electives."

"Major revisions have been made in the civil engineering curriculum. Courses dropped include: structural drafting, engineering society, bacteriology, accounting, law for engineers. Courses added include: humanities - social studies, engineering science, electives."

"In civil engineering the reduction of the number of hours of surveying and structural design has the effect of reducing the amount of time devoted to application and skills, thereby increasing the time available for elective subjects. The increase in the time allotted to dynamics definitely strengthens the background of engineering science."

"For civil engineers there has been a reduction of 33 per cent in advanced surveying."

"Also in both civil engineering and electrical engineering, two of the three introductory shop courses have been dropped."

"The Civil Engineering Department has added as a requirement a course in electrical engineering. This will be for three credits."

"The Civil Engineering Department has gradually converted out old course in foundations to a modern course in soil mechanics. A well equipped soils laboratory is now in full operation."

"Speaking of civil engineering, there was a drastic reduction in surveying with an increase in the amount of electrical engineering, soil mechanics, and advanced mathematics, the last mentioned course for structural engineers only."

"In civil engineering, less emphasis on surveying and structural computations; more emphasis on structural analysis and structural design theory."

"The research activities have grown gradually but with more marked activity in connection with civil engineering."

Encouraging Prospects

Fortunately, discussion centering around the concept of "the engineering curriculum" or even "the civil engineering curriculum" is based upon a misconception. There are great differences in engineering colleges, in their curricula and in the outlook or objectives of their faculties. Several locations have continued over the years to prepare a considerable number of civil engineers for work on the frontiers of technology. We should honor such schools greatly because they have been the benefactors of the civil engineering profession and among the greatest benefactors of this country. By honoring them we would encourage other institutions to join this important group.

The reason why change is slow in education is that every teacher tends unknowingly to try to create students in his own image. Our country has not been attracting a sufficient number of the keenest scientific minds or of broad humanistic minds into civil engineering education. Hence we have not produced strong encouragement of scientific inquiry or of breadth of scholarship in the majority of our civil engineering departments. The report of the Task Committee shows that the profession of civil engineering is likely to pay a heavy penalty in prestige and growth unless it uses all means at its command to stimulate and reward educational progress. It would not strain the ASCE

to award a few $10,000 grants annually to civil engineering departments that had contributed to the advancement of the profession by progress in education or research. The rate of return on this investment might be exceptionally high. At the least, it would prove that civil engineering had become a true profession, since every profession must take a direct interest in its own education.

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SPUTNIKS, FLOPNIKS, AND ENGINEERING EDUCATION[a]

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(Proc. Paper 1872)

The title originally assigned to this paper was, "The Major Strategic Problems Expected to Confront the United States in the Next Decade." These problems can be epitomized by a simple statement: How can we survive as a nation that believes in the basic American concepts of democracy and Christianity?

The question before us as a nation is just that basic and just that brutal. No amount of wishful thinking will solve it; nor will the question cease to exist because we ignore it.

Self-examination is good for the soul. To be effective, however, it must reflect what others think, NOT what we think of ourselves. So as an American who has had considerable opportunity to look at this question through foreigner's eyes, the writer will play the Devil's Advocate to the best of his ability and be brutally frank. He will attempt to say what our foreign guests are too polite to say. He will try to present to you some of the questions, comments, and viewpoints frequently put to him by sympathetic serious-minded friends who are important people in their own countries which extend from the British Isles to East Pakistan.

As background for this problem, the reader should review the place currently occupied in the eyes of the world by the United States as compared to that occupied by the Russians. The so-called uncommitted areas of the world realize that this "Cold War" is a war of extinction, and that if they are forced to commit themselves to one side or the other, they must choose the one that gives the greatest evidence of leadership and virility.

There are many things about us that bother those who could be our friends:

First, they cannot understand why we Americans cannot learn to subordinate our prejudices in an adult fashion and see things as they are and not as we wish them to be.

Second, they cannot understand why we do not accept the fact that because others approach life from a different point of view, they are not necessarily

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wrong. It is always possible that the others may be nearer to the truth than we. It is pointed out that since the dawn of reason all men have sought satisfactory answers to the basic questions of life—what am I, where did I come from, why am I here and where am I going? From the search for answers to these four fundamental questions has sprung all religious and philosophical thought, and what might seem right to one does not have to be right for another.

Third, they feel that if we are to survive we must remove a basic fallacy from our economic thinking—the idea that we can have an economy of plenty indefinitely.

They point out that while the human race tends to increase by geometrical proportions, and agricultural products can be made to increase within limits, fossil fuels and mineral resources do not reproduce and are irreplaceably depleted in direct ratio to the demands made on them by the economy. Hence, if a society is to live long enough to earn a place in history it must place the conservation of its vital irreplaceable wealth at the highest priority. The Russians claim that an "economy of scarcity" is the key to survival and eventual world domination.

They believe that deficit spending and designing for obsolescence can only lead us to financial and material bankruptcy—socialism and then communism.

Fourth, they feel that our national preoccupation with development, improvement, and standardization has so saturated our national thinking that we devote too much of our thought to how to do something better next time. It worries them that we are preoccupied with finding better ways to fight the last war or avoid the last depression or the last international crisis, while others are busy creating new events and thereby retaining the initiative. It is widely believed that if we are to survive we must place the ability to generate new creative ideas and concepts above that of the development and improvement of what exists.

Fifth, they feel that we still do not understand that the Russians have devised a new kind of war. Instead of seeking out the enemy's forces and destroying them, the Russian approach is to maneuver and encourage the enemy to destroy himself by exhausting his natural resources and dissipating his wealth and power in countering widely scattered military threats while the Russian ideology is sold to his enemy's population from within.

They ask, "Why must America accept the pattern of war thrust upon it by Russia—one which has as its prime objective that of causing moral, financial and material bankruptcy?" Haven't the Americans enough creative intelligence to devise another pattern that insures survival of their own way of life?

Sixth, it appears to the thoughtful foreigner that the present American social and economic structure no longer contains many of the basic American concepts that created America, and that many of those which we seem to have discarded have been effectively adapted by the Russians to their system.

Seventh, they remark that the American citizen at home and abroad, when faced with any unpleasant truth about his country's behavior, blames it on his government. Then they remind us that "People get the government they deserve", and they say that, if the people of America cannot get the government they want, the democratic theory is really nonsense.

Eighth, they cannot understand our apparent hypocrisy on the Middle East question. It is an accepted fact outside the United States that the only point of beginning for a solution acceptable to the Arabs lies in first enforcing the

United Nations partition lines of 1947 which the Israelis have violated from the beginning. Yet we persist in ignoring this fact.

In so doing we leave the ace of trumps in Russia's hand from which Nikita finesses effectively. By the union of Egypt and Syria there is formed a militant neutral third party control of the Suez Canal and the land barrier between Persian Gulf Oil and Europe. When Yeman joins the union, the Straits of Aden which dominate the southeast end of the Red Sea can come under this same control. Moreover, if the attempts to bring in Morocco and Oman are successful, the Straits of Gibralter and Oman could also pass to the control of these militant neutrals and with them the control of the Mediterranean Sea and Persian Gulf. The whole Middle East, including our bastion Turkey, could then be isolated without much effort, and NATO would be outflanked and neutralized.

When one considers the size and characteristics of the Russian fleet and its capacity to dominate all of the inland and coastal waters of the Eastern Hemisphere this development takes on a frightening aspect. If it happens, the U. S. will be effectively isolated from the Eastern Hemisphere, and the long term strategy of Peter the Great will have succeeded.

Also one must not overlook the fact that while this is going on in the Eastern Hemisphere, similar operations can be expected in South and Central America aimed at isolating us from the resources of our own front yard. Similar operations in the Far East and Pacific will be aimed at isolating us from the resources of our own back yard. It must be remembered that Sputnik has as great a "Red Herring" potential as regards global strategy as it has a genuine scientific potential with respect to space.

Unless we take the lead now in settling the Palestinian question, which is the major Middle East question, we can expect this new neutral group and all its influences to become increasingly more anti-American.

Although this possibility, which became evident with the revolution in Egypt, doesn't seem to worry us, it most certainly worries those we desperately need as friends and allies. They ask, "Isn't this risk too high a price to pay for a handful of domestic Zionist votes?"

Ninth, they point out that the American concept of democracy guarantees all an equal opportunity to compete, while the American concept of communism appears to guarantee equal participation to all who belong. Yet Communist Russia seems to follow this democratic concept in dealing with education, science and engineering, while Democratic America seems to follow its own definition of communism in dealing with education, labor and foreign aid.

And tenth, as they see us, we make a great noise about being Christian; but they see little evidence of it in our national and international behavior.

We point to our high moral and ethical code but we have very fixed notions about what is right and what is wrong, and we regard as inferior those who are different from us. They think we claim an exclusive possession of righteousness and morals which our behavior does not reflect.

On the other hand they accept the Russian at face value. He proclaims that he is an atheist and in explaining says that he does not believe in a personalized God nor in a life after death. He points out that he accepts the omnipotence of the evolutionary system of nature, and that his ideology is based on the positive evolutionary evidence of nature rather than on the abstract theory of some ancient mystic who personalized religion as a defense against fear. He maintains that true immortality comes from having done something sufficiently significant to deserve a place in history rather than it being individual

everlasting life hereafter. He will say that since immortality is a thing that must be earned in this life, rather than a thing to be gained after death, he has no fear of the hereafter, and that having no fear of the hereafter he is relieved of man's most strangling inhibition—fear.

To the uncommitted this is a powerful argument. One cannot deny that the Christian concept of life as practiced is based primarily on fear of the hereafter; and one cannot deny that fear in some form dominates our lives in the United States. Our present social economic system is built upon fear of discomfort, fear of ill health, fear of being judged different, fear of not being popular, fear of losing economic or social position, fear of not being an economic or social success, etc., etc., etc. Even bargain sales are advertised on the theory of fear of a lost opportunity. In contrast, the Russian maintains that no nation whose social structure is built on fear can possibly produce men of sufficiently uninhibited intellect to dominate the earth and the space around it.

Against this background Sputnik roared into space, apparently as a complete surprise to us. Why it should have been a surprise is difficult to understand. Surprise or not, it had a profound effect on the attitude of the world. This event increased the doubt of our ability to lead the free world, and the adolescent inferiority-based braggadocio with which we responded in the Press, followed by our failure to meet our claims, has caused everyone to reappraise us even more critically than before.

The Russian success in launching Sputnik I and then Sputnik II, followed by our unsuccessful attempts to launch the Vanguard—referred to in the rest of the world as "Flopnik",* has awakened us to the fact that we are engaged in a war of survival. While largely non-military this war is nonetheless total in every respect and one that we are not yet intellectually or psychologically ready to fight.

To date our reaction seems to have been largely confined to the military aspects. There seems to be an idea developing that this new space hardware will require a change in our strategic aims. That is, in the writer's opinion, false and dangerous. First, while new types of military hardware usually lead to changes in tactics, they should not change strategic aims unless they are faulty or incomplete. Second, since it is highly unlikely that the bulk of the human race will indulge in space migration in the next ten years, a sound global strategy should remain adequate.

If the world-wide suspicion that we have no crystallized global strategy is correct, then our most-urgent business is that of formulating one which considers nothing but the survival of what we consider to be worth preserving on this earth. Certainly if we have a crystallized global strategic plan, our diplomatic gyrations in international circles is doing a masterful job of concealing it. A would-be leader who behaves like a modern version of Don Quixote cannot attract intelligent supporters against one who clearly demonstrates that he knows where he is going and that he is getting there.

In the 1830's, Alexis de Tocqueville wrote in "Democracy in America" the following:

> "There are, at the present time, two great nations in the world which seem to tend towards the same end, although they started from different

*Editor's note: This paper was written and presented prior to the U. S. Army's successful "Explorer" satellites, but this success does not modify the author's arguments.

points: I allude to the Russians and the Americans. Both of them have grown up unnoticed . . . All other nations seem to have nearly reached their natural limits, and only to be charged with the maintenance of their power; but these are still in the act of growth. . . . they are proceeding with ease and with celerity along a path to which the human eye can assign no term.

"The American struggles against the natural obstacles which oppose him; the adversaries of the Russian are men; the former combats the wilderness and savage life; the latter, civilization with all its weapons and its arts; the conquests of one are therefore gained by the ploughshare, those of the other by the sword. The Anglo-American relies upon personal interest to accomplish his ends, and gives free scope to the unguided exertions and common sense of the citizens; the Russian centers all the authority of society in a single arm; the principal instrument of the former is freedom, of the latter, servitude. Their starting point is different and their courses are not the same; yet each of them seems to be marked out by the will of Heaven to sway the destinies of half the globe."

This prediction has been quoted many times. Seldom if ever is it used in what is believed to be the true prophetic intention of the author. What he says is still very true about both the Russians and ourselves. The Russians, for centuries, have been engaged in a struggle against all of the weapons and arts that civilization and its politics have developed, while we Americans on the other hand have grown up combatting only nature's wilderness. Like a farm boy, we have no significant experience with the sophisticated problems of complex international life.

Consequently, we entered the cold war with a completely naive attitude toward the world, against the most experienced and the most sophisticated international operator the world has ever seen. While we seem to have arrived at a national age of adolescent romanticism, Russia seems to have arrived at an age of mature Machiavellian sophistication. Russia couples this sophisticated maturity with a revolutionary vigor that is still gaining strength, while we couple our adolescent naivete with a status quo defensiveness which seems to have lost the revolutionary vigor that produced us.

We are engaged in a world-wide battle for men's minds and souls. The side that can discipline itself into producing the best intellects in sufficient numbers will earn survival. History has proved that only those survive who earn the right to survive. The judge in this deadly contest will not be any human tribunal; it will be the unrelenting impartiality of nature's evolutionary system itself.

Disregarding for the moment the other innumerable facets of this ideological contest, there is one vital facet that we must develop to its maximum if we are to survive. It is the capacity to produce creative thinkers, particularly in the fields of science and engineering.

We claim with considerable justification that we have an above-average national school system, that we have a very low rate of illiteracy, and that education is open to all. However, there is considerable evidence that this great school system including the state colleges and universities, geared to give the greatest opportunity to the greatest number, produces primarily an average product. While this may be very necessary to maintain our economic fabric, it does not, except by accident, develop our best intellects to their maximum capacity.

An analysis of the present Russian system, the intellectual products of which are startling the western world, provides much food for thought. Prior to the 1917 Revolution, Russian scientific and technological education, although confined largely to the aristocracy, was nevertheless very sound from an educational point of view. The concept of doing broad and deep original work survived the Revolution and the post-revolutionary Stalin years and it is now a major theme of Russian education.

It is the basic concept of Russian education that sound education must be made available to all those who demonstrate that they deserve it and have the intellectual capacity to use it, and that it must continue until they have reached the maximum of their intellectual development. On the other hand, the Russian holds that training is the development of a skill whether it be mental or physical and is something to which every member of the State must be subjected until he no longer improves; then he must be put to work at that level. This means that from the very beginning those who demonstrate intellectual tendencies are moved along toward education. As they demonstrate that they are approaching the limit of their intellectual capacity their program is shifted to training and there find their way directly into industry.

In common with most of the European countries they do not teach other languages as foreign languages like we do. Rather, they teach second and third languages and they start them at the beginning of school along with Russian. It is reliably reported that of the present study body in Russia below college level, 40% are learning either German or English as their second language, 20% are learning French, Spanish or Italian as their second language, and approximately 5% are taking one of the Asiatic languages such as Chinese, Japanese, Arabic, etc. In their preparatory work it is reliably reported that 53% of the total classwork is devoted to basic and applied mathematics, and to the full range of physical sciences.

With a selective system that constantly filters out those who are least qualified to continue, only the really promising students reach higher education. Although this percentage is small, the volume is not so small. For instance, in the academic year 1956-57 there registered in Russian schools a total of 35 million students, of whom 30 million were in the preparatory section while 3 million were in technical and scientific colleges and 2 million in general universities.

If the yearly output in engineering alone is related to population, Russia in 1957 produced twice as many as the United States, five times as many as the United Kingdom and four times as many as all the rest of industrial Europe. With the students currently enrolled, in 1960 Russia will turn out three times as many as the United States, seven times as many as the United Kingdom and six times as many as industrial Europe.

Although reliable figures were not readily available on the number of scientists being turned out, there is reason to believe that the numbers will approximate 75% of those given for engineers.

These figures may seem alarming, but they are not nearly as alarming as the apparent quality of the individuals produced. There is reason to know that they can be very good. While ours have been trained and taught to learn, theirs have been educated and taught to think!

The Russian system of making everyone earn intellectually what education he gets eliminates from the system all of the chaff that otherwise clogs it. To be of any value an educational system must have the basic characteristics of a threshing machine. Unless the chaff is first separated from the grain, it is impossible to select the best grain for germination.

On top of this basic approach the Russians have superimposed ideas that are basically American. It will be recalled that the American medical profession did an historic thing in regards to medical education. It decided that since it is a learned profession, it should establish its education and training within the discipline of that profession, and not follow the general academic system. It decided that instead of starting from the preparatory level as a base and then learning more and more about less and less, as you approach the top of the academic pyramid, it would permit no specialization below the Doctor of Medicine level in order that specialization would come only after a broad general cultural and professional base had been acquired.

The outstanding success of American medicine has attracted attention throughout the world and particularly in Russia. The Russians are not much concerned with the medical aspects of the preservation of life, since they regard human life as an expendable natural resource. But they were struck with the profoundness of this educational concept. As near as we can tell, they are using much of this approach in producing their scientists and engineers.

There was a very interesting recent article from a reliable source in Germany concerning the social climate within which Russian education is being carried on as contrasted with American procedure. It points out that in the Soviet economy, public consumption has no influence on production but that production is regulated solely to feed the development schemes of the government.

It points out that contrary to the wishful thinking in the United States, to the effect that the Russian people do not support the government's programs, and that the Russian Government is therefore bound to collapse, none of these government schemes could possibly have succeeded without the support of a dependable majority of the people. It also points out that the educational system makes great use of the Russian people's indifference to material possessions and is thereby able to develop a high degree of social prestige for the scholar, the scientist and the engineer. Finally, it points out that teachers are treated with the greatest respect and economic consideration.

The article contrasts this with American pre-occupation with creature comforts and material possessions. It is very critical of the lack of required solid course work in the preparatory schools, of the lack of discipline among American children, of the transfer of responsibility for personality development from the home to the school, and of the absurdity of requiring that all children until the age of sixteen attend public school, because of organized labors' unwillingness to drain off the least intellectually fit into apprenticeships in the trades and industry. It points out the low economic and social positions of the teachers and professors in the United States, and states that there is really no shortage of teachers in the United States, there is only a misuse of them in requiring them to try to teach too many who have no capacity to learn and who should have been physically trained to do something useful and put to work years before.

Another article points out that the major difference between the Russian approach and the American approach is that the Russians are participants while the Americans have become spectators. It notes that indoctrination in Russia is built on the idea that the national evolutionary growth of the Soviet now requires the replacement of the supremacy of Red soldiers with the supremacy of Red engineers and scientists. It observes that the Russian iconoclastic attitude of breaking traditions encourages new approaches to

intellectual development while the American slavish adherence to uniformity discourages new approaches to intellectual development.

During the early part of World War II, the writer was at one time responsible for selecting large numbers of engineers for appointment as officers in the Navy. To do this adequately it was necessary to become thoroughly familiar with all of the engineering curricula in the United States. Later in the Pacific, he had an opportunity to observe a large number of these same engineers in operation. Almost without exception the ones who turned out to be the most effective officers, who demonstrated the greatest capacity to handle men under unusual circumstances, and who demonstrated the greatest capacity for original thinking and ingenuity in unprecedented circumstances, were the ones who had had a broad and basic education in engineering. It seemed that the greater the specialization in application courses or in programs that were highly fragmented or that allowed full use of the so-called elective system, the more inhibited and ineffective in new circumstances the man became.

During 1946 while on duty in Washington, his assignment required that he again review all the engineering curricula in the United States, this time from the standpoint of quality and effectiveness. It was alarming to find that we were developing an even greater amount of undergraduate specialization and fragmentation.

During the time that he was Chief Engineer for the design and construction of the Argonne National Laboratories, the writer had some similarly enlightening experiences. The first difficulty was finding and assembling engineers who did not regard themselves as scientists and who at the same time did not regard real scientists as screwballs. Coupled with this was the equally difficult task of convincing the real scientists that they were not engineers.

Here again the same pattern that was observed in the Pacific became evident. The greater the specialization below the Doctor's level, the greater the man's inability to function in a new situation. Again, the most flexible and the most creative were those who had had the broadest general education.

Now, broad education does not mean a scattered sampling of introductory courses in the humanities and social sciences. Broad education means effective association with competent faculty who have the capacity to develop a student's desire and capacity to think by using the accumulated knowledge of the world as a spring board.

Since the 1930s, it has been increasingly apparent to many practicing engineers in the United States and abroad that our engineering educational system is fast becoming inadequate to meet the needs of our evolving society. The confusion that had developed up to 1947 led the late Dean Mortimer E. Cooley, Honorary Member of the American Society of Civil Engineers and of University of Michigan fame, to write in his autobiography: "For too many years the engineer has been limited, or has limited himself, to the making of the physical environment out of which have sprung the thoughts and actions of others . . . The engineer must be educated to the needed changes in his training which will enable him to take over the responsibilities of leadership that, by virtue of this technical civilization, are so largely his . . . It will be clear that I have no confidence in engineering educators, through their own organizations, to provide for the needs which to me are self-evident. I have come to the conclusion that the engineering educators cannot solve the problem; perhaps it is too close to them. The change in engineering will have to come from the profession itself."

In 1950, Henry M. Wriston, President of Brown University, in his address given at the inauguration of President Millis at Western Reserve University said: "The universities are in crisis also, because their fundamental philosophy is still dominated by Europe. In their formative period German scholarly procedures so captivated the minds of those who brought them home after training abroad that our graduate work, though diverging more and more, nonetheless follows the German model. Two wars revealed the weakness of German scholarship; magnificent in his precision, impressive in its thoroughness, it was markedly deficient in a sense of values. Amoral detachment left the road clear for immoral politics, domestic and foreign. Over attention to method with underemphasis upon values is a serious defect which American universities derived from their German inspiration . . . Moreover, as educational associations gained power, in the name of raising "standards", they subjected institutions to so many requirements that the determination of policy in certain areas is more external than internal. The disintegrating process has reached so advanced a stage that only the greatest administrative skill and firmness can reverse the trend."

It should be noted that the Russians had to make no adjustment in their ideology in moving from amoral German science, from which they have borrowed as heavily as we, to atheisticly based Russian science. On the other hand we Americans have to reorient our whole approach if we are to move from an amoral German science base to a new and effective base that is compatible with our Christian concepts.

This poses the problem that is the essence of our dilemma. Starting from an amoral approach to science how do we successfully compete with Russia's atheistic approach without losing our own Christian moral values? Money won't buy the answer to this question. But we must answer it and answer it right, if we are to survive as Christian America.

Since 1951 we have been carrying on a small controlled experiment in engineering education at the American University of Beirut in Lebanon. This institution is chartered under the Regents of the State of New York and operates to serve the entire Middle East. Within the limits set by seemingly unbreakable academic tradition, trustee reluctance, administrative apprehension, and faculty resistance to new things, we have put together a very broad basic program aimed primarily at putting into practice the theories which these past experiences and observations have formed.

The success of the graduates produced by this six-year basic program in engineering is most encouraging. They have out-performed the competition they have met in that international technical battleground which is the Middle East. Those who have come to the U. S. to do graduate work have all done outstanding work.

However, even at that distance from the United States and with a fair degree of isolation from American control, our greatest obstacle to date has been the fear of all concerned that we will be different. Educational experts from the United States including those of the large foundations praise our results while they deprecate our non-standard methods.

It has taken far more time and effort to find a way to be permitted to do what we have done, than it has taken to do it. The experience has taught the writer that the quest for uniformity in personnel and educational matters is a very frightening Frankenstein brought to life by the pedagogues and statisticians who call their creations the "standard criteria" and the "average man." They are creatures of the punched-card pattern, "standard" models that have

become the gods of mediocrity and the protectors of all incompetents who do not dare to compete with those who, having the courage of their convictions, dare to be different.

In this American age of standardization and uniformity, it takes a very considerable amount of moral courage and an enormous amount of energy just to be an individual. To be different, to do something in a new way, is all too frequently regarded as ample cause for criticism, denouncement, and even social isolation. Yet at no other time in our history has there been such great need, not only for those who can do old things in new ways, but above all for those who can do new things any way.

Throughout our experiment we have had the whole-hearted and enthusiastic support of the practicing engineering profession, American overseas industry, British industries, and the people of the Middle East.

The Russians have also shown interest in our activities and according to Pravda they have done us the doubtful honor of instituting on a national scale some of our unorthodox educational procedures.

It may be recalled that last year among other things the writer recommended that we "establish a 'pilot plant' institution founded on the basic concepts which established American professional engineering, with complete freedom to ignore any and all systems and which is dedicated to developing a process whereby the potential intellectual leaders of our on-coming generations can be adequately trained and educated in Engineering and Technology at a rate which is determined by their own capacity to develop."

Today he wishes to repeat that recommendation and to broaden it to include the physical sciences as well as engineering. Not only is the establishment of one or more of such institutions vital to our survival, but it is immediately possible and relatively inexpensive. All that is really required is complete freedom of action and a reasonable amount of money. There are enough of the required kind of faculty available who would be delighted to break with tradition and do what needs to be done, if they are given some means of assembling and of getting support for the necessary programs.

It is also recommended that, in order that we may gain an effective amount of international maturity and sophistication as rapidly as possible, our elementary and secondary schools be taken out of their provincial insular cocoons and recast on a realistic basis.

To do this, authority to determine who may enter or continue in school must be given back to the teachers—not to administrative appointees, but to the teachers themselves. Foreign languages taught as second languages must be required from kindergarten on. Genuine cultural subjects must be retained and strengthened but the "fresh-air" and "pipe" courses must be removed in order to make room for the solid work that is not now being done. Finally, the work load should be materially increased.

The state colleges and universities must be freed from having to take automatically the graduates of the high schools of the state. Entrance to any institution of higher education must be on a competitive selective basis to be effective. All general college courses must be freed from the insular approach and reoriented on a global base. Spectator sports and other similar activities must be more adequately offset by participant activities.

Organized labor must cooperate by devising a training system that will extract from the academic systems everyone who demonstrates that he is better fitted for that equally important segment of our society, the skilled and

semi-skilled citizen. A first-class machinist or butcher or welder, etc., is far more important and valuable than a second-rate graduate.

Our organized religion must do some soul-searching and come up with answers to the moral side of the problem. Telling us that we should all live as brothers and pray more or go to church more isn't adequate. Pious platitudes will not suffice in this crisis. We need a dynamic restatement of our Christian code that can be accepted by intelligent men as reasonable and workable. We need one that the bulk of Americans will live, not just practice on Sunday.

It must provide us with the spiritual and moral dynamics required for the inspiration and discipline of our individual and collective daily lives, which we need to compete successfully with the virulent atheistic ideology of the Russian.

Above all, we must break this slavish national adherence to uniformity and reestablish the basic American right to be an individual.

Congress is giving the President a large amount of money, supposedly to ensure that we catch up with the Russians. The writer contends, however, that there will be no catching up or even survival for the American way of life unless we get it through our heads that the basic elements required for survival cannot be bought with money alone.

In this deadly competition, creative intellectual capacity and moral socio-political maturity are the basic weapons required for survival. At the moment our arsenal seems badly understocked. However, the writer has an abiding faith in the American people's ability to face facts and deliver the goods. The English are not the only ones in the West who can stand up and deliver under a promise of nothing but blood, toil, tears and sweat. There is far more sinew and tough moral fiber under our bloated bureaucracy, confused behavior, seeming hypocrisy and plush uniform materialism than even our own government realizes.

When informed of the facts and the urgency, the American people can and will forge the vital weapons required to implement the only strategy open to us, namely that of survival on this earth as a moral, intellectually creative Christian nation.

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Journal of

PROFESSIONAL PRACTICE

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PROFESSIONAL EARNING AND SATISFACTION SURVEY OF CIVIL ENGINEERS[a]

Discussion by K. E. McKee

K. E. McKEE,[1] A. M. ASCE.—The Junior Activities Committee of the Kansas City Section of ASCE is to be commended for their efforts in conducting this survey. If we are to understand our profession and its problems, surveys of this type are an absolute necessity. Too often the Civil Engineer feels that his problem is unique, while it actually exists throughout the profession.

With respect to salaries, the writer feels that the committee's presentation of the data is misleading. The average of $9140 is deceptive in that a relatively small percentage of engineers receive that salary. Using the data presented 44 per cent of those responding earn less than $7000, 54 per cent less than $7500, and 75 per cent less than $10,000. The median salary, of those answering the question is between $7000 and $7500. The "average" engineer therefore, earns between $1640 and $2190 a year less than the average salary. The salary ranges tabulated are also poor since 40 per cent of the replies with salaries between $7500 and $15,000 are divided into only two classifications. Additional divisions would provide a more complete picture of the salary distribution.

It is interesting to compare the above salaries with that earned by skilled labor in the same area. A bricklayer ($3.75[2] an hour) working 40 hours a week would earn $7320 a year, excluding a two week vacation and normal holidays. A bricklayer therefore earns more than approximately 50 per cent of the members of ASCE in the Kansas City section. Under these circumstances it is not surprising that salary was found to be the weak point in resisting the threat of unionism.

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a. Proc. Paper 1486, December, 1957, by the Junior Activities Committee, Kansas City Section, ASCE.

1. Research Engr., Structural Analysis Section, Dept. of Mech. Eng. Research, Armour Research Foundation of Illinois Inst. of Technology, Chicago, Ill.
2. Engineering News-Record, Jan. 30, 1958, p. 62.

Paper 1891 December, 1958 PP 1

Journal of

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Proceedings of the American Society of Civil Engineers

ABSTRACTS AND INDEXES FOR PROCEEDINGS, VOL. 84, 1958

(Proc. Paper 1891)

FOREWORD

This index has been prepared in an effort to supply a list of topic headings as a guide to material published in the Proceedings of ASCE during 1958. The abstracts included herein are presented to indicate to the reader what general information can be found in the paper in question. The author listing has been made as complete as possible and includes the names of co-authors, discussers, and committee chairmen of the several reports. Subject headings have been greatly restricted, for the sake of brevity, under three basic rules:

1. Each paper is listed under one primary heading suggested by the name of the technical divisions of the Society. No other entry is made for the paper if that one entry is considered to be sufficient.

2. A secondary listing is used if further classification is essential. In this second listing an attempt is made to place papers published in one Division's Journal also under another Division's name so that readers of the Journal of one Division can be made aware of other papers that might be of interest to them.

3. A geographic listing (by states of the United States and by foreign countries) is recognized where location is of particular importance.

References to discussers of a given paper can be found immediately under the name of the senior author in the author index. Discussion that occurred in more than one calendar year can be traced by referring to the senior author's name in successive indexes, until the closing remarks are located. If discussion is published in the same year as the paper, the listing of this discussion is made directly after the listing of the paper in the subject index. If the discussion appears in the year following the paper's publication, then the subject indexing of that discussion is made in alphabetical order under the appropriate subject heading.

Typical abbreviations used in this index are: Dsc for "discussion," Clo for "closing discussion," Rt for "report," Corr for "corrections," and Chmn for "chairman" of a committee submitting a report. All numbers refer to the number of the Proceedings Paper, no page numbers are included in this index. Immediately following the Proceedings Paper number, the letter and number

Note: Paper 1891 is part of the copyrighted Journal of Professional Practice, Proceedings of the American Society of Civil Engineers, Vol. 84, No. PP 1, December, 1958.

symbols indicate which of the several Division Journals the particular paper appeared in. By referring to the back inside cover of any Division Journal the month of issue of any Journal can be ascertained.

Items indexed are identified by months as follows:

Month	Number
January	Proc. Papers 1494 to 1527
February	1528 to 1559
March	1560 to 1579
April	1580 to 1620
May	1621 to 1657
June	1658 to 1691
July	1692 to 1724
August	1725 to 1749
September	1750 to 1789
October	1790 to 1832
November	1833 to 1858
December	1859 to 1891

Journals published during 1958 are as follows:

Month	Journals
January	Engineering Mechanics, Highway, Irrigation & Drainage, Structural, Waterways & Harbors
February	Hydraulics, Power, Sanitary Engineering, Soil Mechanics & Foundations
March	Pipeline, Structural, Waterways & Harbors
April	City Planning, Engineering Mechanics, Hydraulics, Irrigations & Drainage, Power, Sanitary Engineering, Surveying & Mapping
May	Highway, Soil Mechanics & Foundations, Structural, Waterways & Harbors
June	Air Transport, Hydraulics, Pipeline, Power, Sanitary Engineering
July	Engineering Mechanics, Sanitary Engineering, Structural, Surveying & Mapping
August	Hydraulics, Power, Soil Mechanics & Foundations
September	Irrigation & Drainage, Sanitary Engineering, Structural, Waterways & Harbors
October	Engineering Mechanics, Highway, Hydraulics, Power, Soil Mechanics & Foundations, Structural
November	Hydraulics, Sanitary Engineering, Structural, Surveying & Mapping
December	City Planning, Hydraulics, Irrigation & Drainage, Power, Professional Practice, Soil Mechanics & Foundations, Structural, Waterways & Harbors

1879. Elasti-Plastic Analysis of Continuous Frames and Beams, by Lawrence P. Johnson, Jr., and Herbert A. Sawyer, Jr. (ST) An analytical solution considering both elastic and plastic flexural deformations is presented for continuous beams and frames. The method has limitations characteristic of limit design methods except that it determines strength as defined by the moment-curvature relationship as well as an ultimate moment, and allows ready determination of deflections.

1880. Discussion of Proceedings Paper 1197, 1662. (HY) J. Bogardi corrections to 1197. Howard M. Turner on 1662.

1881. Discussion of Proceedings Paper 1645, 1648, 1649, 1654, 1655. (SM) R. G. Ahlvin, D. Hugh Trollope on 1645 A. A. Eremin on 1648. A. A. Eremin on 1649. D. P. Krynine, Dean R. Freitag on 1654. J. MacNeil Turnbull on 1655.

1882. Discussion of Proceedings Paper 1638, 1708, 1709, 1710, 1712, (ST) B. R. Cooke on 1638. Arthur N. Gilbert on 1708. Arthur N. Gilbert on 1709. Arthur N. Gilbert on 1710. Arthur N. Gilbert, Louis Balog on 1712.

1883. Discussion of Proceedings Paper 1486. (PP) K. E. McKee on 1486.

1884. Discussion of Proceedings Paper 1514, 1568, 1571. (WW) Louis H. Foote closure to 1514. C. L. Bretschneider corrections to 1568. J. E. Chappelear on 1568. Basil W. Wilson on 1571.

1885. Discussion of Proceedings Paper 1620. (CP) Nathan Cherniack, William H. Claire, Joseph Horowitz on 1620. Sergei N. Grimm Closure to 1620.

1886. Las Morochas Gas Turbine Power Plant, by A. J. Michael. (PO) This paper presents civil engineering aspects of gas turbine power plants which are different from the more conventional type of thermal power plant.

1887. Civil Engineering Features of TVA Steam Electric Stations, by George P. Palo, Walter F. Emmons, and Nathan E. Way. (PO) Since 1949 the TVA has built seven large steam electric stations. This paper presents features which are of interest in the design of steam plants.

1888. Ocean Cooling Water System for 800 MW Power Station, by Robert H. Weight. (PO) The use of ocean water for cooling must provide for corrosion effects and control of fish and marine growth. This paper describes model studies assuring economical control and handling of water quantities used, with consideration to earthquake and subsidence.

1889. Water Supply to Thermal Power Plants, by E. J. Stankiewicz. (PO) This paper examines water quantities required, sources, circulating water systems and uses, and reviews the water supply systems for several power stations.

1890. Experiments on Self-Aerated Flow in Open Channels, by Lorenz G. Straub and Alvin G. Anderson. (HY) Measurements of air-concentration distribution in high velocity open-channel flows indicate that air content can be related to the flow characteristics and can be described by turbulence concepts.

1891. Abstracts and Index to Proceedings, Volume 84 (1958), by the Board of Direction. (BD) A list of abstracts and a subject and author index have been prepared for all Proceedings Papers published in 1958; the numbers covered are 1494 to 1890. The subject headings used were taken from the names of the technical divisions of the Society; other headings were added when deemed necessary. By use of the author index, it is possible to trace all the discussion that a paper has received.

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EKBERG, CARL E.
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WHITE, WILLIAM A.
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WHITTON, REX M.
"The Role of the State in the Highway Program" (1622HW2)

WHITSETT, HARRY E.
See Shea, Paul H. (1727SM3)

WIEGEL, R. L.
"Breaking Wave Force Prediction" (1573WW2) with R. E. Skjei
Clo (1616HY2) to "Ocean Wave Forces on Circular Cylindrical Piles" (1199HY2) with K. E. Beebe and James Moon

WILCOX, B. W.
"Tidal Movement in the Cape Cod Canal, Massachusetts" (1586HY2)

WILDER, A. B.
Dsc (1691PL2) of "Hydrostatic Testing of Pipelines" (1375PL3)

WILEY, JOHN S.
Clo (1614SA2) to "Liquid Content of Garbage and Refuse" (1411SA5)
Dsc of 1411SA5: P. R. Krige, G. H. Teletzke (1614SA2)

WILLETS, DAVID B.
Dsc of 1359IR2: Robert O. Thomas (1615IR2)

WILKAS, BERT C.
Rt: "Six Thousand High School Students View Engineering and Scientific Careers: Report of the Student Activities Committee, San Diego Section" (1868PP1)

WILLIAMS, DAVID
"A Water-Borne Runway" (1658AT1)

WILLIAMS, G. M.
"Needs of the Interstate System of Highways" (1804HW3)

WILLIAMS, GORDON R.
Dsc (1856HY6) of "Northeastern Floods of 1955: Flood Hydrology" (1663HY3)

WILLIAMS, HARRY A.
See Benjamin, Jack R. (1656ST3)
See Benjamin, Jack R. (1723ST4)

WILLIAMS, J. C., Jr.
See McPherson, M. B. (1558HY1)

WILLIAMSON, ROBERT A.
Dsc of 1631ST3: Victor R. Bergman (1857ST7)
"Moments in Continuous Beams on Flexible Supports" (1631ST3)

WILLIS, J. A.
See Popov, E. P. (1495EM1)

WILLSON, R. J.
Dsc of 1589IR2: Frederick L. Hotes (1784IR3)
"USBR's Lower-Cost Canal Lining Program" (1589IR2)

WILSON, BASIL W.
Dsc (1884WW5) of "Forces Induced on a Large Vessel by Surge" (1571WW2)

WILSON, JOHN S.
See Stevens, William C. (1639WW3)

WINTER, GEORGE
Dsc of 1519ST1: Marvin A. Larson, Bruce G. Johnston, A. Chibaro, Giles G. Green (1787ST5)
"Lateral Bracing of Columns and Beams" (1561ST2)
See Mason, R. E. (1792EM4)

WITHEROW, J. L.
"Anaerobic Contact Process for Treatment of Suburban Sewage" (1849SA6) with J. B. Coulter and M. B. Ettinger

WITTE, LESLIE P.
See Polivka, Milos (1657SM2)

WOLKO, H. S.
See Ranov, T. (1629ST3)

WOLVIN, JOHN H.
"Engineering Uses of Sonne Strip Photography" (1668PL2)

WOOD, LYMAN W.
"The Factor of Safety in Design of Timber Structures" (1838ST7)

WOODRUFF, GLEN B.
Dsc of 1709ST4: Arthur N. Gilbert (1882ST8)
"Wind Forces on Structures: Fundamental Considerations" (1709ST4) with John J. Kozak

WOOLTORTON, F. L. D.
Dsc (1657SM2) of "Laterite Soils and Their Engineering Characteristics" (1428SM4)

WRIGHT, DOUGLAS T.
Dsc (1522ST1) of "Vehicle Loads and Highway Bridge Design" (1302ST4)
Dsc (1522ST1) of "Application of AASHO Specifications to Bridge Design" (1320ST4)
Dsc (1619EM2) of "Plastic Design of Cover Plated Continuous Beams" (1495EM1)
See Nelson, H. M. (1831EM4)

WRIGHT, KENNETH R.
"Model Approach to a Groundwater Problem" (1862IR4)

WU, T. H.
Clo (1559SM1) to "Relative Density of Shear Strength of Sands" (1161SM1)
"Geotechnical Properties of Glacial Lake Clays" (1732SM3)

WYLIE, PAUL E.
See Smirnoff, M. V. (1595SU1)

YERLICI, VEDAT A.
"Reinforcement in Continuous Concrete Pavements" (1799HW3)

YONG, R. N. Y.
Dsc (1828SM4) of "The Engineering Behavior of Compacted Clay" (1655SM2) with B. P. Warkentin
See Warkentin, B. P. (1828SM4)

YOUNG, J. C.
"Application of Interstate Highway Design Standards" (1624HW2)

YOUNG, Y. F.
"An Analytical and Experimental Study of Helicoidal Girders" (1756ST5) with A. C. Scordelis

YU, C. W.
"Review of Limit Design for Structural Concrete" (1878ST8) with Eivind Hognestad

ZAID, MELVIN
"Bending of Elastically Supported Rectangular Plates" (1719EM3) with Marvin Forray

ZASLAVSKY, A.
Dsc (1522ST1) of "Selection of the Gross Section for a Composite T-Beam" (1313ST4)

ZEE, CHONG-HUNG
"Pore Pressure in Concrete Dams" (1597PO2)

ZICK, L. P.
"Spherical Containment Shell of the Dresden Station" (1601PO2) with J. T. Dunn and J. B. Maher

ZIMMERMANN, RICHARD Z. JR.
Clo (1787ST5) to "The Design of Rigid Frame Bents" (1434ST6)
Dsc of 1434ST6: James M. Gere, Joseph J. Hromadik, D. A. Mackenzie, A. A. Eremin (1576ST2)
Dsc of 1434ST6: F. J. Tamanini, Howard H. Mullins, R. E. Bowles, Robert B. Harris, Albert D. M. Lewis (1656ST3)

ZOBEL, E. C.
See Fertis, D. G. (1820ST6)

ZOLLER, J. HAROLD
"Snowmelt Runoff" (1834HY6) with Arno T. Lenz

ABSTRACTS

January

1494. Matrix Analysis of Beams, by Ray W. Clough. (EM) The application of a matrix procedure to the analysis of structures consisting of flexural members is presented in this paper. Four examples demonstrate the application of the method to various types of structures.

1495. Plastic Design of Cover-Plated Continuous Beams, by E. P. Popov and J. A. Willis. (EM) According to the plastic method of design, an infinite number of alternative designs of cover-plated continuous beams for the same applied load is possible. Several designs of two-span continuous beams were made, and experimental evidence was obtained to serve as justification for this method of design.

1496. Sea Bottom Pressure Fields Produced by Yawed Vessels, by P. M. Fitzpatrick. (EM) The flow around a stationary ellipsoid immersed in a semi-infinite fluid medium is examined. Approximation equations are given for the pressure distribution on the plane boundary and a procedure for obtaining constant pressure contours is presented.

1497. Teamwork in the Solution of Water Problems, by Harvey O. Banks. (IR) This paper presents aspects of teamwork in the uses of water, considering teamwork among agencies, and between professional groups and the public.

1498. Engineering in the Soil Conservation Service, by C. J. Francis. (IR) This paper outlines engineering activities of the Soil Conservation Service. Emphasis is placed on the engineering aspects of the new Watershed Protection and Flood Prevention Program, Public Law 566, which is administered by the Soil Conservation Service.

1499. Can Evaporation Losses be Reduced? by Earl Harbeck, Jr. (IR) A number of methods of minimizing evaporation losses are presented in this paper. Two methods that warrant intensive study are the use of a monomolecular film, such as hexadecanol, on the water surface, and the use of ground-water reservoirs for storage.

1500. Water Supply Versus Irrigation in Humid Areas, by M. C. Boyer. (IR) Watershed inventories are necessary to assure maximum beneficial use of the water supply, and to determine the present and future needs. White River Basin, Indiana, is so inventoried.

1501. Resolving Conflicting Demands for Water, by Samuel B. Morris. (IR) In arid areas of the world such as those of the Nile and Colorado Rivers, irrigation use creates major international problems. Domestic-industrial use can give the most benefits, but advanced planning is necessary to avoid conflicts.

1502. Importance of Phreatophytes in Water Supply, by C. B. Thompson. (IR) This paper outlines the occurrence and spread of salt cedar (tamarisk) over 440,000 acres in New Mexico. Water use and methods of eradication and control are examined.

1503. Factors Affecting the Useful Life of Reservoirs, by Carl B. Brown. (IR) The useful life of reservoirs includes length of life and service value. Controlling factors in reservoir silting are the capacity-inflow ratio and sediment content of inflow, which is governed by watershed characteristics. Flexibility in design and site conservation through proper project formulation is urged.

1504. Influence of Climate on Irrigation Agriculture, by Wayne D. Criddle. (IR) Climate is the major factor that determines whether irrigation is necessary in an area. Growing season rainfall may limit the amount of irrigation water needed, but may also create problems that do not exist where summer rainfall is scarce.

1505. Hydraulic Properties of Perforated Well Casings, by Yoash Vaadia and Verne H. Scott. (IR) This paper deals with the hydraulic performance of well casings of varied perforation characteristics. Several commercially perforated casings were tested in combination with various gravel envelopes. Results are presented and compared with criteria already available for well screens.

1506. Drainage in Relation to a Permanent Irrigation Agriculture, by C. R. Maierhofer. (IR) After trying for some 5,000 years to establish a permanent irrigation agriculture in arid lands, man finally has the knowledge and tools to assure success. Selecting lands for permanent productivity under irrigation is one practical answer.

1507. Methods of Computing Consumptive Use of Water, by Wayne D. Criddle. (IR) The more generally used methods for computing consumptive water requirements of crops are summarized, and data and charts that may simplify the application of methods are presented.

1508. Design of Folded Plate Roofs, by Howard Simpson. (ST) The procedure for the analysis of a single-span folded plate structure is reviewed and analyzed with the aid of an illustrative example. The effects of relative displacements of the longitudinal edges are considered.

1509. A Method of Design of Reinforced Concrete Sections, by Panagiotis D. Moliotis. (ST) A general solution is given in this paper of the calculation of any section of reinforced concrete with a symmetry axis, eccentrically loaded.

1510. Ultimate Strength Analysis of Long Hinged Reinforced Concrete Columns, by B. Broms and I. M. Viest. (ST) Theoretical analyses of the strength of slender concentrically and eccentrically loaded columns are presented and compared with existing test data. Both the effect of bucklings and the increase of eccentricity caused by deflections are taken into account.

1511. The Structural Properties of Magnetite Concrete, by Jerome M. Raphael. (ST) Structural design of a magnetite-concrete reactor shield depends on elastic and volumetric properties of the material. Principles are given for proportioning concrete mixtures made of crushed magnetite. Tests are described to establish the suitability of mixture under temperature and moisture conditions of the reactor, as well as elastic properties for design of steel reinforcement.

1512. Design of Masonry Walls for Blast Loading, by K. R. McKee and E. Sevin. (ST) The arching action theory of masonry walls is applied to the problem of blast resistant design. An equation of motion is developed for a masonry beam of solid cross section restrained by essentially rigid supports. Comparison is made with test data for walls subjected to full scale atomic and high explosive blasts.

1513. New Retractable Marine Fender System, by Palmer W. Roberts and Virgil Biancato. (ST) This paper presents details of a retractable marine fender system of a continuous timber vertical member and horizontal wale frame suspended by bolts in slotted brackets fastened to the pier. The outstanding qualifications of this system are large energy absorption, economy and permanence.

1514. The Columbia River Controlled, by Louis H. Foote. (WW) Planning by the Corps of Engineers for development of the water resources of the Columbia River Basin will consider changed conditions and needs since the Corps' report of 1948. This paper outlines these changes and the problems being encountered in providing long-range plans for resource development.

1515. Hydraulic Problem Solution on Electronic Computers, by Edward A. Lawler and Frank U. Druml. (WW) Applications are presented of three types of electronic computers, demonstrating the wide range of problems solved by these instruments. Tedious methods of solution are replaced by more accurate methods, thus freeing the engineer for true engineering problems.

1516. Closure of the Breach in Bayocean Peninsula, Oregon, by Harlan E. Brown, Jr., Gerald D. Clark, and Robert J. Pope. (WW) This paper examines the design and construction of rock and sand fill closure structures for Bayocean Peninsula, a natural barrier between Tillamook Bay and the Pacific Ocean, which was breached by storm waves.

1517. Flood Control in New England, by Alden K. Sibley. (WW) This paper considers flood-control methods employed for protection against both river and tidal flooding as related to the unique topographic, hydrologic, and economic characteristics of New England.

1518. St. Lawrence Seaway, 27-ft Canals and Channels, by W. Grothaus and D. M. Ripley. (WW) A historical summary of the 27-ft St. Lawrence Seaway is followed by an examination of the criteria adopted in design of the Seaway. Dams, locks, and channels of the project are presented with reference to these hydraulic criteria.

1519. Tentative Recommendations for Prestressed Concrete: Report of the Joint ACI-ASCE Committee on Prestressed Reinforced Concrete. (ST) The objective of this report is to recommend those practices in design and construction which will result in prestressed concrete structures that are comparable both in safety and in serviceability to constructions in other materials now commonly used.

1520. Discussion of Proceedings Paper 1138, 1157, 1290, 1292, 1399. (EM) Yoshiaki Iwasa, Alfred C. Ingersoll, Masashi Hom-ma

on 1138. J. W. Delleur closure to 1138. Frank Baron closure to 1157. John H. Percy on 1290. Arne Selberg on 1292. S. J. Medwadowski on 1399.

1521. Discussion of Proceedings Paper 1104, 1105. (IR) Harry F. Blaney closure to 1104. George H. Hargreaves closure to 1105.

1522. Discussion of Proceedings Paper 1055, 1101, 1146, 1147, 1149, 1150, 1151, 1189, 1255, 1302, 1303, 1304, 1309, 1312, 1313, 1315, 1316, 1318, 1320, 1353, 1357, 1433. (ST) P. B. Morice and H. E. Lewis closure to 1055. No closure notice to 1101. Harry H. Hill closure to 1146. Frank Baron closure to 1147. Nan-Sze Sih closure to 1149. E. Chesson, Jr. and W. H. Munse closure to 1150. Harry Subkowsky closure to 1151. Eivind Hognestad closure to 1189. Louis Balog on 1255. Douglas T. Wright on 1302. H. S. Makowski, Thomas D. Y. Fok on 1303. P. W. Abeles on 1304. Irving Sherman on 1309. S. K. Ghaswala on 1312. A. Zaslavsky on 1313. E. Neil W. Lane on 1315. Milos Vorlicek and Jan Suchy, Ernest Basler, Rene E. Walther on 1316. Yeshayahu Etkin on 1318. Herbert A. Sawyer, Douglas T. Wright, Michael E. Fiore and Thomas R. Kuesel, Henri Perrin on 1320. Kurt H. Gerstle on 1353. E. Neil W. Lane on 1357. E. George Stern on 1433.

1523. Discussion of Proceedings Paper 1119, 1208, 1211. (WW) Alexander H. Konigsberg closure to 1119. Otakar W. Kabelac closure to 1208. R. Silvester on 1211.

1524. Road Development in Ontario, by W. J. Fulton. (HW) Results of an engineering study which estimates the highway needs of Ontario for the next twenty years are given in brief. Organization of Department of Highways is outlined.

1525. Adaptability of Interchange Types on Interstate System, by Jack E. Leisch. (HW) This paper recommends types of interchanges based on analyses and comparisons of operational features and capacity potentials. A scheme is presented to provide operational uniformity in conjunction with exits on the interstate system of highways.

1526. Discussion of Proceedings Paper 1090, 1250, 1372, 1385. (HW) Paul Hartman closure to 1090. G. I. Sawyer on 1250. T. F. Hickerson on 1372. H. A. Abdun-Nur on 1385.

1527. The Administrative Role of the Federal Government in the Interstate System, by Frank C. Turner. (HW) Because it is not possible for 67 million motor vehicles to stay within the boundaries that have been set up to subdivide residents in urban areas, more effective cooperation must be developed across these boundaries if the highway program provided by the Federal Aid Highway Act of 1956 is to bring needed traffic relief.

February

1528. Turbulence Characteristics of the Hydraulic Jump, by Hunter Rouse, T. T. Siao, and S. Nagaratnam. (HY) Hot-wire measurements of turbulence in an air-flow model of the hydraulic jump are described for Froude numbers of 2, 4, and 6. Results are analyzed and interpreted in the light of momentum and energy integrals.

1529. The Haas Hydroelectric Power Project, by J. Barry Cooke. (PO) Engineering considerations, design criteria, and construction data for a high head hydroelectric project are presented. The features of this project are an underground power house, a 290-ft-high rockfill dam, an unlined pressure tunnel, and multiple-jet, vertical-shaft impulse turbines.

1530. The Total Sediment Load of Streams, by Emmett M. Laursen. (HY) Relationships are proposed that give the quantity and quality of the total, suspended, and bed loads as functions of the stream and sediment characteristics. In the process of empirically defining the relationships, a correlation of laboratory and field data was obtained.

1531. Sediment Transport in Money Creek, by J. B. Stall, N. L. Rupani, and P. K. Kandaswamy. (HY) A hydraulic study was made of Money Creek and sediment capacity determined by the Einstein, Schoklitsch and DuBoys formula. Utilizing flow duration information, the total quantity of bed material moved is calculated. Actual bed material size sediment is compared with the sediment transport.

1532. Field Investigations of Spillways and Outlet Works, by Benson Guyton. (HY) Included in the Corps of Engineers hydraulic field testing program are flood-control and multiple-purpose projects, river and harbor works, and estuarine and wave problems. Test data examined include spillway, conduit-intake, and gate-leaf pressures; air demand, and concrete friction factors.

1533. Media Characteristics in Water Filtration, by Gaurchandra Ghosh. (SA) A study has been made on the effect of media characteristics in water filtration. Data are presented

which show that the current ideas regarding turbidity penetration and removal of turbidity in the top layers of the filter are misconceptions.

1534. Sewage Disposal in Santa Monica Bay, California, by C. G. Gunnerson. (SA) The results of receiving water studies made in connection with the expansion of Los Angeles' Hyperion Treatment are reviewed and analyzed in terms of the degree of treatment required for effluent discharged five miles offshore.

1535. Model Study of a Dynamically Loaded Pile, by Roy D. Gaul. (SM) Tests made on a model of a vertical pile in soft soil indicate that a low frequency oscillatory lateral load induces pile bending moments that correspond to moments caused by the same load applied statically. Computation of pile moments appears to agree with dynamic test results.

1536. Dewatering Excavation, Low Sill Structure, Old River, La., by C. I. Mansur and R. I. Kaufman. (SM) This paper presents the results of pumping tests performed to determine the adequacy of a system of deep wells installed to lower the piezometric head in a deep stratum of pervious sand underlying the excavation for the structure.

1537. A Method to Describe Soil Temperature Variation, by E. B. Penrod, W. W. Walton, and D. V. Terrell. (SM) Values for thermal diffusitivity, temperature, and temperature amplitude were determined from observed data. These constants were used in an equation to describe the variation of temperature with time at any soil depth. Calculated temperatures and mean observed soil and air temperatures are plotted for comparison.

1538. Discussion of Proceedings Paper 1216, 1285, 1350. (PO) S. Logan Kerr, R. S. Quick on 1216. John Parmakian closure to 1216. G. R. Latham closure to 1285. George A. Whetstone, Stavros N. Nicolau on 1350.

1539. SED Research Report No. 14: A Survey of the Present Status of Refuse Engineering and Development. (SA) Results of the investigations of the professional status of refuse collection and disposal is stated, and data on new developments and improved practice is reviewed. Reference is made to a previous report (SED Research Report No. 11).

1540. SED Research Report No. 15: Possible Contributions by Sanitary Engineers to Air Pollution Research. (SA) The paper reviews lack of research in air pollution among sanitary engineers, in spite of special training. Main features include essential areas of investigation in both the laboratory and field.

1541. SED Special Report: Engineer's Joint Council Policy Statement on Air Pollution and its Control. (SA) This paper covers the development and need for an E.J.C. statement on air pollution, and certain principles of air pollution, general considerations, causes and methods of control.

1542. Water Quality in the Missouri River, by Glen J. Hopkins and Joe K. Neel. (SA) The paper examines the quality of water in the Missouri River from the standpoint of reservoir influences and pollutional influences. Factors considered are turbidity, hardness, alkalinity, and algae. Bibliography.

1543. The Effects of Air Pollution on Airport Visibility, by William T. Ingram and Louis C. McCabe. (SA) Air pollution seriously impairs visibility at New York City airports. Possible sources of pollution are given, and related meteorological conditions are described. It is brought out that until improvement in airport visibility is achieved, flights must depend on instrument flying during periods of critical visibility.

1544. Cement and Clay Grouting of Foundations: Present Status of Pressure Grouting Foundations, by A. Warren Simonds. (SM) Present-day uses of pressure groutings are described. Recent developments and improvements of drilling and grouting equipment, and also of grouting materials are mentioned. Examples of successful grouting are cited where core drilling has produced rock cores from foundations with cracks and seams well filled and bonded with cement grout.

1545. Cement and Clay Grouting of Foundations: Grouting with Clay-Cement Grouts, by Stanley J. Johnson. (SM) The uses of suspension grouts consisting of soil or soil and cement are reviewed, with a discussion of the design of grout mixtures.

1546. Cement and Clay Grouting of Foundations: The Use of Clay in Pressure Grouting, by Glebe A. Kravetz. (SM) This paper reviews properties, preparations, and testing of clay, clay-chemical, clay-cement, and clay-sand-cement grouts. Field techniques are cited.

1547. Cement and Clay Grouting of Foundations: The Use of Admixtures in Cement Grouts, by Alexander Klein and Milos Polivka. (SM) Aspects of the use of admixtures are presented with respect to grout mixtures. Types of admixtures, test equipment, and methods of testing are examined. Typical relationships among grout properties are illustrated.

1548. Cement and Clay Grouting of Foundations: Suggested Specifications for Pressure Grouting, by Judson P. Elston. (SM) In the field of foundation treatment, it is improbable that all problems arising during construction can be anticipated by the designer or specification writer. A workable and equitable specification can be resolved from previous experience and practices, geological data, design criteria, and the capabilities of the engineer confronted with a new foundation site.

1549. Cement and Clay Grouting of Foundations: Pressure Grouting with Packers, by Fred H. Lippold. (SM) The use of packers for controlling the injection of grout into a rock foundation is presented. A description of common types of packers currently being used is given, with comments on their adaptability to rock foundations. Advantages and disadvantages of the procedure are cited.

1550. Cement and Clay Grouting of Foundations: French Grouting Practice, by Armand Mayer. (SM) European experience has indicated that clay and clay cement grouts can be utilized to successfully control seepage through alluvial materials. Descriptions of foundation conditions, grouting programs and nature of the grout mix are given for four projects: Genissiat cofferdam, Fessenheim open pit, Ait Ouarda cofferdam, and Serre-Poncon dam.

1551. Cement and Clay Grouting of Foundations: Practice of the Corps of Engineers, by Edward B. Burwell. (SM) The cement grouting practice of the Corps of Engineers during the last decade has adhered closely to a well-established pattern of design and procedure. This paper outlines this practice, and the current grouting specifications requirements of the Corps.

1552. Cement and Clay Grouting of Foundations: Experience of TVA with Clay-Cement and Related Grouts, by George K. Leonard and Leland F. Grant. (SM) Most of the dams built by the TVA have required large amounts of grouting for foundation preparation. Clay-cement grout has been used where feasible, and it has been possible to obtain safe and watertight foundations at a much lower cost than by using usual neat-cement grout.

1553. Trajectory Bucket-Type Energy Dissipators, by E. A. Elevatorski. (PO) Factors in the design of trajectory bucket-type energy dissipators are given in this paper, with data from model and prototype tests. For all contemplated structures recourse to laboratory model studies should be made to refine or verify the merits of each design.

1554. Underground Power Houses in Italy and Other Countries, by Claudio Marcello. (PO) This paper presents the characteristics of a number of underground power houses mainly constructed in Italy on the writer's design or with his cooperation. The criteria aiding in the choice of the solutions adopted are given special attention.

1555. The Sudagai Underground Power Plant, Japan, by Tatsuo Mizukoshi. (PO) A description of the Sudagai project is presented, with attention given to costs and methods of excavation and concreting, model studies, and seismic forces.

1556. Montgomery Dam—Rock Fill with Asphaltic Concrete Deck, by F. W. Scheidenhelm, John B. Snetlage, and Arthur N. Vanderlip. (PO) This paper describes various aspects of design and construction of a rock-fill dam with an asphaltic concrete deck. The advantages and economy of this type of dam construction are cited.

1557. Discussion of Proceedings Paper 1078, 1115, 1178, 1224, 1274, 1336. (SA) No closure notice to 1078. Donald J. O'Connor and William E. Dobbins closure to 1115. John R. Snell closure to 1178. Marvin L. Granstrom closure to 1224. Tsung-Lien Chou on 1274. Leon E. Chase on 1336.

1558. Discussion of Proceedings Paper 882, 1038, 1162, 1166, 1167, 1197, 1202, 1260, 1262, 1266, 1331, 1332, 1345, 1395. (HY) No closure notice to 882. Hunter Rouse closure to 1038. A. M. Moore closure to 1162. David K. Todd closure to 1166. M. B. McPherson, H. S. Strausser, and J. C. Williams, Jr., closure to 1167. Vito A. Vanoni and Norman H. Brooks; E. Roy Tinney; M. L. Albertson, D. B. Simons, and E. V. Richardson on 1197. John F. Neville closure to 1202. Mushtaq Ahmad on 1260. Corrections to 1262. Gale B. Dougherty on 1266. T. Blench on 1331. M. B. McPherson on 1332. F. V. A. Engel on 1345. H. C. Riggs on 1395.

1559. Discussion of Proceedings Paper 1143, 1161, 1301, 1309, 1427, 1428. (SM) Elbert E. Esmiol closure to 1143. T. H. Wu closure to 1161. Yoshichika Nishida on 1301. Irving Sherman on 1309. Edward S. Barber on 1427. Edward S. Barber on 1428.

March

1560. Analysis of Braced Frames, by Kurt H. Gerstle. (ST) A method of analysis for knee-braced frames is presented. Values of fixed support forces, distribution factors, and carry-over factors are given. Procedure is explained by means of an example problem.

1561. Lateral Bracing of Columns and Beams, by George Winter. (ST) It is often necessary to determine the characteristics required of lateral bracing to counteract buckling of columns and beams. An elementary method is developed for calculating lower limits of strength and rigidity of lateral support in order to provide full bracing. This is defined as equivalent to immovable support.

1562. Numerical Solutions for Beams on Elastic Foundations, by Henry Malter. (ST) Two methods for the solution of beams on elastic foundations are considered. One is a step-by-step integration process and the other, using finite difference equations, obtains a solution by a set of simultaneous equations. Examples are solved and comparisons made between the results.

1563. Earthquake Response of Elevated Tanks and Vessels, by Donald F. Moran and James A. Cheney. (ST) Recent western United States earthquakes, while not as severe as can be expected to occur, have provided tests of many structures specifically designed to resist earthquake forces. A method of analysis is considered where minor damage to elevated water tank towers and refinery vessels can be explained.

1564. Analysis of Open-Spandrel Arches, by A. F. Diwan. (ST) This paper presents a mathematical solution for the open-spandrel arch. The solution is based on the principle of balancing the panel moments by imposing therein a special type of panel distortion which produces moments of a known pattern in the chords of the deformed panel only.

1565. The Design of the Main Towers of the Mackinac Bridge, by Kuang-Han Chu. (ST) Design aspects of the main towers of the Mackinac Straits Bridge are described in this paper. Design specifications are introduced, and principles of preliminary design are examined. Loading conditions, methods used, and results obtained in the final analysis are presented. Design aspects of details are also described.

1566. An Elastic Criterion for Plastic Design, by Herbert A. Sawyer, Jr. (ST) The significance of the elastic limit to deflection, local instability, and plastic fatigue in plastic design is investigated. An elastic limit criterion for plastic design is proposed.

1567. Moments in Restrained or Continuous Beams by the Method of Partial Moments, by Harry Posner. (ST) This paper presents a method of obtaining moments in beams by obtaining moments at each support with loading placed on one span at a time, and getting the moments at each support with all the spans loaded by combining these moments.

1568. Selection of Design Wave for Offshore Structures, by Charles L. Bretschneider. (WW) Methods are presented for the selection of the design wave, crest elevation, wave length, and maximum horizontal particle velocity at the crest for offshore structures. Wave data supplemented by wave theory are used for the development of generalized graphs for use with waves of finite height.

1569. Shipboard Hydraulic Breakwater, by R. A. Dilley. (WW) A model hydraulic breakwater was constructed on a 1:86.5 scale model Liberty Ship. Curves depicting the relationship between wave attenuation and jet flow, and the dependence of mooring forces on wave height are given.

1570. The Welland Canal, By W. A. O'Neil. (WW) The history of this Canadian canal is given from its inception in 1824. Planning criteria, detailed design information, and traffic data are presented. Original construction methods, maintenance problems, and solutions are examined. Plans are described for deepening the canal to St. Lawrence Seaway standards.

1571. Forces Induced on a Large Vessel by Surge, by John T. O'Brien and D. I. Kuchenreuther. (WW) Field measurements are presented of forces up to 40 kips induced by head-on standing waves of 1 and 2½ minute periods in lines of a 12,000-ton ship moored by unusually taut lines.

1572. Contractor's Planning for Navigation Locks, by F. J. Larkin. (WW) This paper deals with job planning for navigation locks and is concerned with selection of a construction plant. The construction of the Markland Locks Project on the Ohio River for the Corps of Engineers serves as an illustration.

1573. Breaking Wave Force Prediction, by R. L. Wiegel and R. E. Skjei. (WW) Laboratory data of the kinematics of waves breaking on a model beach are analyzed. Resulting water

particle velocities and accelerations are used in the Morison-O'Brien-Johnson-Schaaf wave force theory to predict the force field for piles of three different diameters. Comparisons of results with predictions from a modified solitary wave theory are given.

1574. Pipeline Location Surveys, by Earl K. Monteith. (PL) The many problems faced by the locating engineer are varied, and the economics of any pipeline project are affected by decisions made in the field. This paper deals with the most common problems of the locating engineer.

1575. Digital Computers Applied to Pipeline Design, by Harold E. Thomas. (PL) This paper, in examining the application of digital computers to pipeline design problems, stresses the possibility of evaluating solutions under varying conditions in order to select the most desirable design.

1576. Discussion of Proceedings Paper 1187, 1188, 1190, 1303, 1353, 1355, 1356, 1357, 1431, 1432, 1434, 1510. (ST) Benjamin C. F. Wei closure to 1187. E. Czerniak closure to 1188. Haaren A. Miklofsky and Omar J. Sotillo closure to 1190. Louis Balog on 1303. Thomas C. Coleman, Thomas D. Y. Fok on 1353. Herbert S. Saffir on 1355. Kuang-Han Chu, Myle J. Holley and Vitelmo Bertero, I. Earl Lewis, Jr. on 1356. Bruce G. Johnston, Paul J. Brennan on 1357. Kuang-Han Chu on 1431. Paul Spindel on 1432. James M. Gere, Joseph J. Hromadik, D. A. Mackenzie, A. A. Eremin on 1434. G. C. Ernst on 1510.

1577. Water Distribution Problems Solved by Network Calculators, by L. M. Haupt. (PL) The alternating current network calculator is an analogue computer that can be adapted to the solution of pipeline distribution problems. This paper describes the use of this computer on this type of problem.

1578. Discussion of Proceedings Paper 1195. (PL) Robert D. Kersten and Edwin J. Waller closure to 1195.

1579. Discussion of Proceedings Paper 1366. (WW) Samuel Heyman, Cevdet Z. Erzen on 1366.

April, 1958

1580. Dynamic Analysis and Response of Aircraft Arresting Systems, by Robert S. Ayre and Joel I. Abrams. (EM) An analysis of aircraft arresting systems, as lumped parameter systems omitting the effect of wave travel in the cable is presented. Comparison with small-scale experimental results, and response spectra of maximum cable tension under a wide range of operating conditions are included.

1581. On Inelastic Buckling in Steel, by Geerhard Haaijer and Bruno Thurlimann. (EM) A theoretical and experimental study on inelastic buckling of steel columns and plates is presented, including results of tests on model columns, angles and wide-flange beams. Recommendations are given for required geometric proportions of wide-flange shapes in plastic design.

1582. Eisenhower and Grass River Lock Models, by Martin E. Nelson and Harvey J. Johnson. (HY) The lock models described in this paper simulated, to a scale of 1 to 24.24, (model to prototype), upper and lower approach channels and lock chambers. The hydraulic systems consist of intake ports in the upper gate sill, culverts and ports in the chamber walls, and lateral culvert diffusers in the lower approach.

1583. Thermal Density Underflow Diversion, Kingston Steam Plant, by Rex A. Elder and Gale B. Dougherty. (HY) The solution to the diversion of cold thermally stratified density underflows up a side river channel and through a canal whose bottom is higher than the channel is presented.

1584. Submerged Sluice Control of Stratified Flow, by Donald R. F. Harleman, Robert S. Gooch, and Arthur T. Ippen. (HY) Results are presented of experimental and analytical studies on the selective withdrawal of water from reservoirs or rivers in which density stratifications due to thermal or other effects occur.

1585. Mechanical Analogs Aid Graphical Flood Routing, by Max A. Kohler. (HY) Graphical techniques for routing directly on the plotted hydrograph charts are described, and mechanical analogs facilitating graphical solutions are examined. An analog has been constructed which will accommodate the use of graphical relations for inflow versus lag, and storage versus outflow.

1586. Tidal Movement in the Cape Cod Canal, Massachusetts, by B. W. Wilcox. (HY) Variations in the form of the tide wave at selected points, analyses of observations to obtain harmonic constants, and a method for predicting tidal currents in the canal are presented. Diagrams show the shapes of the tide curve.

1587. Distribution of Sediment in Large Reservoirs, by Whitney M. Borland and Carl R. Miller. (HY) The factors affecting the sediment distribution in a reservoir are examined and two methods are presented by which the probable distribution can be predicted.

1588. Water Distribution Design and The McIlroy Network Analyzer, by M. B. Mc-

Pherson and J. V. Radziul. (HY) The paper illustrates time-distribution of demand rates, design rates and equalizing storage requirements for certain Philadelphia districts. Efficacy of perfectly-balanced system characteristics and utilization of the McIlroy Analyzer for design in Philadelphia are described. Merits of different types of computers are compared.

1589. USBR's Lower-Cost Canal Lining Program, by R. J. Willson. (IR) This paper describes the growing problem of water deficiency in the west and examines several methods of lining waterways to alleviate water loss. Advantages and disadvantages of each method are cited.

1590. Water Yields as Influenced by Watershed Management, by Robert H. Burgy. (IR) Studies show that appreciable increases in runoff result from replacement of brush by grass. Factors in precipitation disposal relating to influence of watershed vegetation on runoff are examined.

1591. Irrigation in New Jersey, by Robert L. Hardman. (IR) This paper describes the recent rapid growth of irrigation, and examines available water, and experimental studies. The need for protective legislation to control consumptive use of water in humid states is commented on.

1592. Water Intakes in the Detroit River, by Eugene A. Hardin. (SA) A new water supply system will serve the communities of the southeastern part of Wayne County, Michigan. Features are a water intake in the Detroit River and a raw water tunnel extending inland to a pumping station and purification plant. Other intakes of the Detroit River are also examined.

1593. Highway and Bridge Surveys: Reconnaissance, Progress Report of the Committee on Highway and Bridge Surveys. (SU) The importance of good reconnaissance in the selection of new highway routes is underscored. The conduct of reconnaissance is described and essential elements of the reconnaissance report are enumerated.

1594. Geodetic Control for Tropospheric Scatter Antennas, by Max O. Laird and Antonio Aguilar. (SU) This paper examines second and third-order triangulation expansions controlling the aiming of highly directive antennas, boundary, topographic and construction surveys, at radio stations providing public telephones and network television services between the United States and Cuba.

1595. Short Methods in Adjustment of Observations, by M. V. Smirnoff and Paul E. Wylie. (SU) Adjustment of observations in one and two variables which must conform to a straight line, natural or logarithmic are considered. Formulas for the adjustment by the method of least squares are presented as a possible substitute for the formal application of the method.

1596. Effect of Deflection on Lateral Buckling Strength, by J. W. Clark and A. H. Knoll. (EM) The effect on lateral buckling strength of the deflection or curvature that occurs in an initially straight beam or beam-column prior to buckling is investigated. An analytical study of beams and an experimental investigation of beam-columns are presented.

1597. Pore Pressure in Concrete Dams, by Chong-Hung Zee. (PO) This paper analyzes pore pressure in concrete dams. The mechanics of uplift force acting within a concrete body by conceiving the concrete as a space frame structural body are examined.

1598. Ambuklao Underground Power Station, by Andrew Eberhardt. (PO) Power features of the Ambuklao Project in the Philippines are described. An underground power station was constructed at a site which offered complex rock conditions. A feature of this power station is the horizontal shaft setting of the generating units.

1599. Insurance Aspects of Nuclear Energy, by Edward K. Lloyd. (PO) The paper presents an insight into nuclear energy insurance. Syndicates or insurance pools formed to write insurance on nuclear facilities are described in detail. Insurance rates for nuclear risks and amounts of insurance available to industry are explained.

1600. Civil Engineering Aspects of the Dresden Nuclear Power Station, by Joseph E. Love, Chester S. Darrow, and Burr H. Randolph. (PO) Design considerations arising from the layout of nuclear power equipment within a vaportight sphere are examined. Problems of more conventional nature are related to nuclear power plant design.

1601. The Spherical Containment Shell of the Dresden Station, by L. P. Zick, J. T. Dunn, and J. B. Maher. (PO) Problems encountered in the fabrication and erection of a spherical pressure vessel are presented. Special features are a containment housing around a nuclear power plant including a dual support system, access locks and unusual shell penetrations.

1602. Civil Engineering Aspects of the Fermi Atomic Power Station, by Pharo C. Burg and John G. Feldes. (PO) This paper describes processes employed in converting atomic energy into electricity at the Enrico Fermi Atomic Power Station. Arrangement of equipment and design considerations are examined, showing effect and relation to site development and structures housing principal equipment.

1603. Densities and Compaction Rates of Deposited Sediment, by Victor A. Koelzer and Joe M. Lara. (HY) This paper presents a

review of important work concerning density and consolidation of deposited sediment as related to reservoir deposits. Attention is given to work in soil mechanics that has application in sediment consolidation.

1604. Incremental Compression Test for Cement Research, by A. Hrennikoff. (EM) This paper describes a compression test of cement and concrete that separates immediate deformation from creep. This determines elastic and inelastic characteristics describing the stress-strain properties of material and the internal mechanics of deformation and failure under load.

1605. Discussion of Proceedings Paper 1306. (SU) J C Carpenter on 1306.

1606. A National Water Quality Basic Data Program, by Ralph C. Palange and Stephen Megregian. (SA) This paper presents the Public Health program for collection of data on water quality, providing chemical, biological, and radiological analyses of the nation's water resources on a long-term basis.

1607. Water Intakes in the Niagara River and Lake Ontario, by Raymond H. N. Murray. (SA) This paper examines design conditions of the intakes for the towns of Tonawanda and Oswego, New York, and covers the intake cribs and lines.

1608. Digital Computers for Pipeline Network Analysis, by Quintin B. Graves and Don Branscome. (SA) This paper on digital computers for the solution of pipeline network problems sets forth one of the recent developments which should provide added economy in engineering design.

1609. Maintenance of Fine Bubble Diffusion, by Philip F. Morgan. (SA) Diffuser media for air diffusion may be clogged externally by a number of specific materials, and internally by particulate matter in the air supply. Procedures to control external clogging and a new air quality standard to eliminate internal clogging are presented.

1610. SED Research Report No. 16: Refuse Composting Experience in the Netherlands. (SA) Results of the Netherlands pioneering work in large scale municipal refuse composting through a government financed agency are reviewed.

1611. SED Research Report No. 17: Color Removal from Azo Dye Wastes. (SA) The efficiencies of treating ten azo dyes with stannous chloride for color removal have been determined. Color may be removed by heating the dye waste in the presence of stannous chloride, a powerful reducing agent.

1612. Advances in Secondary Processes of Sewage Treatments in the Period, October 1, 1954 to June 1, 1957. Report by the Sub-Committee—Section III of the Committee on Sewerage and Sewage Treatment. (SA) This paper examines secondary processes such as activated sludge, trickling filters and stabilization ponds. Factors of design and operation are reviewed and statements on radioactive and detergent materials are cited.

1613. A Study of Sewage Collection and Disposal in Fringe Areas: Progress Report of the Committee on Public Health Activities of the Sanitary Engineering Division. (SA) The accelerated growth of the urban fringe around American cities during the last three decades has created problems in providing community facilities. Providing these services is a challenge to professional groups and the public.

1614. Discussion of Proceedings Paper 928, 1408, 1411, 1461. (SA) Edwin A. Wells, Jr., and Harold B. Gotaas closure to 928. D. I. H. Barr on 1408. P. R. Krige, G. H. Teletzke on 1411. John S. Wiley closure to 1411. John W. Cunningham on 1461.

1615. Discussion of Proceedings Paper 1236, 1352, 1359, 1360, 1362, 1499, 1507. (IR) H. W. Adams closure to 1236. Harry F. Blaney on 1352. Robert O. Thomas on 1359. R. G. Cox, Steponas Kolupaila and John F. Kennedy on 1360. O. Starosolszky, Steponas Kolupaila, Armando Balloffet on 1362. Robert O. Thomas on 1499. Robert O. Thomas in 1507.

1616. Discussion of Proceedings Paper 1199, 1200, 1331, 1393, 1395, 1401, 1402, 1403, 1405, 1401-1406, 1401 and 1405, 1406, 1453. (HY) R. L. Wiegel, K. H. Beebe, and James Moon closure to 1199. Benjamin A. Whisler and Charles J. Smith closure to 1200. Vito A. Vanoni, Hsin-Kuan Liu on 1331. Theodor S. Strelkoff on 1393. G. N. Alexander, Max A. Kohler, Ralph W. Powell on 1395. E. A. Elevatorski, A. Rylands Thomas on 1401. A. Rylands Thomas on 1402. A. Rylands Thomas on 1403. A. Rylands Thomas, Earl J. Beck on 1405. W. H. R. Nimmo, Walter Rand on 1401-1406. Solano Vega-Vischi on 1401 and 1405. John R. Argue on 1406. Turgut Sarpkaya on 1453.

1617. The Geodimeter and Tellurometer, by Austin C. Poling. (SU) These electronic distance measuring instruments are examined relative to basic electronic principles. Methods of field operation are given. Line measurements with the geodimeter are compared with those obtained by other methods and accuracies are described.

1618. Discussion of Proceedings Paper 1397, 1398, 1414, 1420, 1488. (PO) F. L.

Lawton on 1397. F. L. Lawton on 1398. M. H. Benson on 1414. Joseph R. Bowman on 1420. Clifton W. Bolieau on 1488.

1619. Discussion of Proceedings Paper 1141, 1196, 1290, 1390, 1495. (EM) Joseph Penzien closure to 1141. W. Nachbar closure to 1196. Kurt H. Gerstle closure to 1290. Zdenek Sobotka on 1390. Douglas T. Wright on 1495.

1620. Some Aspects of Urban Planning, by Sergei N. Grimm. (CP) This paper analyzes the urban planning concept, land use planning and its relation to transportation, planning of industrial and residential areas and community facilities, and coordinated use of regulatory and other devices for the guidance of land development.

May

1621. Connecticut Highways and the 1955 Floods, by Newman E. Argraves. (HW) Details of emergency and long-term restoration of the structures and road locations damaged or destroyed by the 1955 floods are presented in this paper.

1622. The Role of the State in the Highway Program, by Rex M. Whitton. (HW) This paper presents the functions of the state in carrying out the expanded federal aid highway program. Program planning, location and plan development, supervision of construction, and maintenance of the system are examined in relation to the state.

1623. Ground Transportation at New York International Airport, by Richard I. Strickland. (HW) A new concept in airport terminals resulted in a 655-acre "Terminal City" which will include 10 passenger terminal buildings, 10 miles of two-lane roads, and multiple parking facilities. Basic planning data and design of the roadway system are presented.

1624. Application of Interstate Highway Design Standards, by J. C. Young. (HW) Minimum design standards set up to govern design and construction of the Interstate Highway System are examined, with reference to their applications.

1625. Continuous Origin and Destination Traffic Surveys, by S. T. Hitchcock. (HW) A system of collecting origin and destination information on a continuing basis using a permanent staff and statistical methods already adopted in continuous traffic counting programs would provide reliable information with technique improvement and possible reduction on costs.

1626. Quality Control for Large Highway Projects, by E. A. Abdun-Nur. (HW) This paper describes an approach to quality control dictated by factors inherent in large-scale accelerated programs, and stresses application of control to materials and construction operations.

1627. Correlation of Geometric Design and Directional Signing, by George M. Webb. (HW) Directional signing must be given consideration during the earliest planning and design stages. This requires that engineers be fully cognizant of each other's problems. This paper examines these factors and presents certain basic principles for guidance of all concerned.

1628. Integrated Planning of Highways and City Streets, by Guy Kelcey and George Leland. (HW) The paper illustrates integrated planning of a system of arterial highways and city streets in a metropolitan region, with aspects of development assuring future growth and economic well-being of the region considered.

1629. The Location of Maximum Principal Stresses, by T. Ranov and H. S. Wolko. (ST) Principal normal and shearing stresses in transversely loaded beams have extrema between neutral axis and most distant fiber when the "load-section" parameter M/Vk has values between certain limits which depend on the geometry of the cross section. These limits are presented for rectangular sections and for commonly used I-beam profiles.

1630. The New Art of Fabrication Engineering, by Frederick H. McDonald. (ST) Fabrication engineering is presented as a new subject in education and for the control of design in practice. It is defined as the art of determining the materials, methods and places of assembly to assure maximum use and competitive values for the products of engineering design.

1631. Moments in Continuous Beams on Flexible Supports, by Robert A. Williamson. (ST) A procedure is given for determining end moments in continuous beams on elastically deflecting supports by balancing the angle changes resulting from introducing imaginary hinges at supports. Moments are obtained by successive corrections re-establishing continuity. Application is illustrated by a numerical example.

1632. Design Features of Lower Deck of George Washington Bridge, by Irvine P. Gould. (ST) The addition of a lower deck for the George Washington Bridge follows the concepts of the original designers. The bridge expansion will take place without exceeding the contemplated design loads. The approaches must be modified and built with minimum interference to the 36,000,000 vehicles using the bridge annually.

1633. Report of Committee on Deflection Limitations of Bridges. (ST) This paper reviews the history and purpose of limitations on

span-depth ratio and deflection-span ratio of the AASHO Specifications for Highway Bridges. Dynamics of bridge vibration from both the structural and psychological point of view are examined.

1634. Rigid Frame Analysis with the Aid of Digital Computers, by E. Czerniak. (ST) This paper shows how rigid frame type structures may be analyzed through existing general purpose mathematical programs. Examples including a multibay gabled bent and lean-to frames with tapered girders demonstrate the simplicity of the method. Effects of foundation settlement, shrinkage, and temperature changes are included.

1635. Ultimate Strength Analysis of Long Restrained Reinforced Concrete Columns, by Bengt Broms and I. M. Viest. (ST) Theoretical analyses, based on idealized stress-strain diagrams for concrete and steel, are presented for the strength of slender concentrically and eccentrically loaded columns restrained at both ends. The effects of end restraints, of the increase of eccentricity caused by deflections and of buckling are taken into account.

1636. Use of Modern Computers in Structural Analysis, by Ray W. Clough. (ST) The paper reviews considerations involved in performing structural analyses by electronic digital computers. A scheme for handling calculations by a series of matrix operations is given, and a bibliography on matrix and computer analyses of structures is included.

1637. Specifications for Preservative Treatment of Timber: Progress Report of a Sub-Committee of the Committee on Timber Structures. (ST) The purpose of this report is to provide recommendations for the application of various types of preservative in addition to brief descriptions of the preservatives currently in common usage.

1638. Lateral Load Analysis of Two-Column Bents, by John E. Goldberg. (ST) Simple equations involving only joint rotations are presented for symmetrical two-column bents subjected to lateral loads. Iterative, algebraic and composite solutions are demonstrated.

1639. Waterfront Structure Design for Varying Conditions, by W. C. Stevens and J. S. Wilson. (WW) A review of the different designs of pier and wharf structures constructed by the Port of New York Authority during the past ten years is presented. Effects of site conditions and functional requirements on each of six major projects are examined and resulting construction described.

1640. Wave Run-Up on Roughened and Permeable Slopes, by Rudolph P. Savage. (WW) Laboratory tests determining run-up on various beach slopes as a result of wave action are described. Curves relating the run-up to wave steepness, slope roughness, and slope permeability are presented.

1641. Railroad Bridge Alterations, Calumet-Sag Project, by George W. Svoboda. (WW) The widening of the Calumet-Sag project waterway requires the alteration of numerous railroad bridges whose expense is shared by bridge owners and the federal government. Problems from the standpoint of cost apportionment, planning, and negotiation of construction agreements with bridge owners are detailed and complex.

1642. Calumet River Lock, Calumet-Sag Project, Illinois, by W. J. Santina and E. G. Hoffmann. (WW) This new navigation lock will involve departures from usual design in that lock walls and guide walls will be of steel sheet piling construction, with concrete construction being limited to gate blocks. Lock gates will be of the sector type, with a total span of 110 feet.

1643. Calumet-Sag Navigation Project, by John B. W. Corey. (WW) A serious obstacle to navigation on the Illinois Waterway will be removed when improvements to the Calumet-Sag Channel have been completed. Barge tows four times larger than present will then be able to connect with deep-draft navigation at Lake Calumet.

1644. Stability of Coastal Inlets, by Per Bruun and F. Gerritsen. (WW) Existing theories of the relationship between tidal range, tidal prism, and inlet cross section are reviewed and compared. Data on inlets and the effect of the quantity and type of littoral material on inlet action are examined.

1645. Increased Resistance to Deformation of Clay Caused by Repeated Loading, by H. B. Seed, R. L. McNeill and J. de Guenin. (SM) The influence of stress history in the form of a series of repeated stress applications, in increasing the resistance to deformation of compacted specimens of silty clay is described. The significance of results in assessing the design life of highway pavements is reviewed.

1646. Geology and Soils of the Newark (N. J.) Metropolitan Area, by Alfreds R. Jumikis. (SM) This paper examines major soil types encountered in the glaciated Newark area, presents physical properties of the glacial soils, and indicates the practical applications of engineering soil maps.

1647. Development of Multiple-Wheel CBR Design Criteria, by C. R. Foster and R. G. Ahlvin. (SM) This paper presents an improved method for developing multiple-wheel CBR design criteria from proven single-wheel criteria. The development of the method and its applications are illustrated.

1648. Symposium on Geological Factors in Tunnel Construction: Tools and Techniques, by Arthur B. Cleaves. (SM) Types of geologi-

cal investigations essential to delineating potential tunnel problems, and new core boring aids are described.

1649. Symposium on Geological Factors in Tunnel Construction: Geology and Tunnel Design, by A. B. Reeves. (SM) The geologist-engineer relationship in tunnel design and construction is outlined. Methods of investigation, selection of tunnel location, and factors to be considered in the preparation of designs and specifications for tunnels are examined.

1650. Symposium on Geological Factors in Tunnel Construction: Geophysical Investigations for the Lehigh Tunnel, by H. LeRoy Scharon and Arthur B. Cleaves. (SM) This paper describes investigations conducted in the portal areas of the Lehigh Tunnel on the Pennsylvania Turnpike System which were made for the purpose of indicating the approximate depths to solid bedrock.

1651. A New Rubberized Asphalt for Roads, by J. York Welborn and John F. Babashak, Jr. (HW) This paper shows that the addition of minute quantities of sulfur to natural rubber latex during blending greatly improves the properties of rubberized asphalt. Asphalt prepared by this method should reflect in improved performance when used for surface treatment.

1652. Discussion of Proceedings Paper 1250, 1374, 1380, 1385, 1525, 1625. (HW) Scott H. Lathrop and Francis J. Farias closure to 1250. Charles E. De Leuw, Karl Moskowitz on 1374. Paul L. Nichols on 1380. José A. J. Salas and V. Escario on 1385. G. D. Love on 1525. J C Carpenter on 1625.

1653. Discussion of Proceedings Paper 1211, 1514. (WW) J. W. Johnson closure to 1211. Roy F. Bessey on 1514.

1654. The Structure of Compacted Clay, by T. W. Lambe. (SM) This paper describes the nature of clay structure, a term referring to the arrangement of particles and the electrical forces acting between them. The effects of forces and environmental factors on structure are inferred from the principles of colloid chemistry and crystal chemistry.

1655. The Engineering Behavior of Compacted Clay, by T. W. Lambe. (SM) This paper employs the principles of colloid chemistry and crystal chemistry to give a physical explanation of the engineering behavior of compacted clay. The relationship between clay structure and behavior is described and illustrated with experimental data.

1656. Discussion of Proceedings Paper 1057, 1100, 1233, 1234, 1254, 1255, 1312, 1315, 1354, 1356, 1433, 1434, 1436, 1437, 1519, 1560, 1561, 1565. (ST) Alfred L. Parme closure to 1057. No closure notice to 1100. E. Neil W. Lane corrections to discussion, T. F. Hickerson closure to 1233. Guillermo Villena closure to 1234. Jack R. Benjamin and Harry A. Williams closure to 1254. Ardis White and William B. Purnell closure to 1255. J. M. Pickett closure to 1312. T. Y. Lin closure to 1315. E. Neil W. Lane on 1354. Kuang-Han Chu corrections to discussion, I. M. Nelidov on 1356. John Steinbrugge on 1433. F. J. Tamanini, Howard H. Mullins, R. E. Bowles, Robert B. Harris, Albert D. M. Lewis on 1434. James I. Rooney, A. A. Eremin on 1436. A. S. Hall, Alan M. C. Holmes corrections, Victor R. Bergman on 1437. A. W. Coutris, T. Y. Lin on 1519. George D. Siegfried on 1560. William Zuk on 1561. Kuang-Han Chu corrections to 1565.

1657. Discussion of Proceedings Paper 941, 1160, 1204, 1205, 1299, 1301, 1427, 1428, 1429, 1439, 1537, 1545. (SM) Ray W. Clough and David Pirtz closure to 941. Eben Vey closure to 1160. Milos Polivka, Leslie P. Witte, and John P. Gnaedinger closure to 1204. Jack W. Hilf closure to 1205. No closure notice to 1299. S. J. Johnson on 1301. F. E. Richart, Jr. closure to 1301. D. P. Krynine on 1427. Jacques de Medina, F. L. D. Wooltorton, S. F. Gizienski on 1428. John A. Trantina on 1429. A. A. Eremin on 1439. D. C. Pearce on 1537. Robert W. Cunny on 1545.

JUNE

1658. A Water-Borne Runway, by David Williams. (AT) This paper describes a method of building a runway in which the concrete surface is supported on shallow thin-walled rubber water-bags. Heavy wheel loads are thus transformed into a small uniform hydrostatic pressure on the foundation soil. The constructional problem is examined and model tests are described.

1659. Airport Approach, Runway and Taxiway Lighting Systems, by C. Edward Walter and Vincent J. Roggeveen. (AT) This paper describes various systems of approach, threshold, runway, and taxiway lights. These are evaluated by means of a set of design criteria developed from a series of principles of guidance needed by an aircraft pilot.

1660. Regulation of Lake Ontario, by Franklin F. Snyder and Robert H. Clark. (HY)

The physical characteristics of the Great Lakes, the hydrology of Lake Ontario, and regulation studies of the Great Lakes during the past half century are outlined. Latest international studies for regulation of Lake Ontario are described.

1661. Northeastern Floods of 1955: Meteorology of the Floods, by Charles S. Gilman and Kendall R. Peterson. (HY) This paper, one of three of a symposium, examines physical reasons for occurrence of the rainfall. Part of the explanation is the connection between rain-producing and energy-producing processes; another is the inertia of the winds. A series of maps is presented which illustrates these processes.

1662. Northeastern Floods of 1955: Rainfall and Runoff, by Tate Dalrymple. (HY) This second paper in the symposium lists peak discharges for selected gaging stations, and a comparison is made with the rainfall causing them. A comparison is also made with past floods and some indication of the frequency of the floods is presented.

1663. Northeastern Floods of 1955: Flood Control Hydrology, by Elliot F. Childs. (HY) This third paper describes the meteorology, flood discharges, and the effect of these events on hydrologic design criteria for flood control structures.

1664. Skin Friction Experiments on Rough Walls, by G. M. Sanks. (HY) Rough, flat plate skin friction at high Reynolds numbers is shown to be determinable from experiments at moderate Reynolds numbers in an identically roughened pipe. The effect of peripheral wires on skin friction in a pipe is correlated with the measured drag of a circular cylinder on a plane wall.

1665. Sewage Pumping, by H. H. Benjes. (SA) This paper describes pumping equipment, including types of pumps, and illustrates standard terms used in specifying pump characteristics and mechanics of pump selection.

1666. Highway Engineers and Pipeliners can Solve Mutual Problems, by C. D. Richardson. (PL) The ever-increasing pipeline and highway systems in the United States have magnified the mutual construction problems of highway engineers and pipeliners. Examples demonstrate benefits available to all from mutual cooperation.

1667. Flow Equations for Natural Gas Pipelines, by R. F. Bukacek. (PL) Flow equations used in the natural gas transmission industry are examined in relation to their application. Factors determining resistance to flow are related to the operating conditions of natural gas pipelines to show the limitations inherent in any practical flow equation.

1668. Engineering Uses of Sonne Strip Photography, by John H. Wolvin. (PL) Design features of the Sonne aerial camera are reviewed as an aid to the understanding of unique performance features. Specific examples of engineering uses are stated together with suggested flight specifications. Uses of stereo photography for determination of terrain cross sections are covered.

1669. Municipal Financing of Airports, by Rollin F. Agard. (AT) Municipal government has played an important role in the development of the aviation industry by providing a system of airports financed primarily from bond issues. Substantial sums will be needed to provide facilities for increasing air traffic. Airlines and other users must assume a greater portion of the cost of providing and operating these facilities.

1670. Underground Power Plants in Canada, by A. W. F. McQueen, C. N. Simpson, and I. W. McCaig. (PO) This paper presents factors affecting design practice in Canada and describes two large underground powerhouses at present under construction in the Province of Quebec. Reference is made to the Kemano development in British Columbia.

1671. Kenney Dam and Cheakamus Dam in British Columbia, by William G. Huber. (PO) Site and materials data, design criteria, construction procedures and some performance records are presented in this paper on two zoned rockfill dams in British Columbia, one founded on rock and the second on a mud slide.

1672. Box Canyon Hydroelectric Project, by Arthur P. Geuss. (PO) Design and construction of the main spillway dam of the Box Canyon Project is described in this paper, together with other project features including the powerhouse, diversion tunnel, forebay channel, and auxiliary spillway.

1673. Pipeline Field Welding and Quality Control Methods, by A. G. Barkow. (PL) History of pipeline-laying in the United States is traced, with emphasis on the application of weld-

ing. Welding technique, specialized equipment associated with welding, qualification procedures, and non-destructive test methods are examined.

1674. Future Prospects for International Pipelines, by William R. Connole. (PL) Although international pipelines are now physically possible, considerations of national self-interest must be settled first. A re-examination and clear statement of policy by both Canada and the United States must precede random expansion of international pipelines.

1675. Underground Power Plants in Scotland, by C. M. Roberts. (PO) The development, layout and construction of the Ceannacroc and Glenmoriston underground power plants in Northern Scotland is described. Tunneling methods, access and ventilation, surge arrangements, migratory fish and flood control provisions are examined.

1676. Civil Engineering Features of Linden Generating Station, by A. Verduin. (PO) The paper illustrates the civil engineer's role in the design and construction of a major steam electric generating station. This station is unique because of the interchange of extraction steam for refining residuals with a nearby oil refinery.

1677. SED Research Report No. 18: Municipal Incinerator Design, A Survey of Engineering Practice. (SA) This paper presents a survey of 110 cities in the United States using incinerators. Evaluation of construction trends and costs are presented along with design data and operation information.

1678. SED Research Report No. 19: Sewage Treatment by Lagoons. (SA) This report covers the economy and space involved in this method of treatment. Data and information are presented on installations and design criteria.

1679. Sewage Effluent Used for Industrial Water, by Thomas F. Sullivan. (SA) The paper describes the water and sewage effluent available and means used to overcome undesirable constituents to produce a water capable of performing the task assigned to it.

1680. Organization of Metropolitan Districts, by Langdon Pearse. (SA) Examples of cooperative action by municipalities are the New York Port Authority and The Metropolitan Sanitary District of Greater Chicago. Data are given on such organizations in the United States and Canada, including interstate pollution control agreements.

1681. Effects of Aeration Period on Modified Aeration, by Wilbur N. Torpey and Martin Lang. (SA) Five years of operating data are analyzed to find the effect of the aeration period on process efficiency and air consumption. A region of operation from zero aeration period to the minimum necessary for full process efficiency is defined.

1682. Design of Water Supply Structures, by Howard J. Carlock. (SA) The paper is a resume of seven subjects related to water supply and representing ideas that engineers are continually developing to further improvements in design.

1683. Performance and Maintenance of Dix River Dam, by Lewis A. Schmidt, Jr. (PO) Constructed to a height of 275 feet in 1923-25, Dix Dam was then the highest rockfill dam built. Accumulated data on leakage, maintenance, condition and settlement are presented for applicable consideration in the design of future projects similar to the Dix River Dam.

1684. The Turbulent Boundary Layer in a Conical Diffuser, by Harvey R. Fraser. (HY) A method for turbulent boundary layer calculations in a smooth walled conical diffuser is proposed, based on the analysis of the boundary layer in two distinct regions and involving only the solution of algebraic equations.

1685. Salaries of Local Environmental Health Personnel in 1956, Report of the Committee on Salaries. (SA) This report is the second in the series covering the salary status of the environmental health personnel in 1956.

1686. A Study of Sewage Collection and Disposal in Fringe Areas: Second Progress Report of the Committee on Public Health Activities. (SA) In this Second Progress Report, the Committee presents Appendices B, C, D, and E to supplement the First Progress Report published as Proceedings Paper 1613 in the April, 1958 Journal of the Sanitary Engineering Division.

1687. Cogswell and San Gabriel Rockfill Dams, by Paul Baumann. (PO) Features of interest attending the design, construction and performance of two rockfill dams are treated in this paper. Attention is paid to such novel features in the design and construction as have proved to be advantageous and successful.

1688. Discussion of Proceedings Paper 1408, 1461, 1463, 1533. (SA) Alex N. Diachishin on 1408. C. J. Posey on 1461. J. Fleming Dias on 1463. H. E. Hudson, Jr. on 1533.

1689. Discussion of Proceedings Paper 1457, 1488, 1529, 1554, 1555. (PO) D. J. Bleifuss, F. L. Lawton, Pierre E. Danel and Jean Rueff on 1457. D. I. H. Barr on 1488. F. L. Lawton on 1529. F. L. Lawton on 1554. F. L. Lawton on 1555.

1690. Discussion of Proceedings Paper 1449, 1451, 1453, 1454, 1455, 1528. (HY) M. B. McPherson, J. W. Forster on 1449. H. C. Riggs and Manuel A. Benson on 1451. Steponas Kolupaila, Ralph W. Powell, John W. Paull, Iwao Oki on 1453. R. E. Templeton and T. E. Stelson on 1454. Madhav Manohar, Fred W. Blaisdell, W. T. Moody, Jean Rigard, M. B. McPerson, Steponas Kolupaila on 1455. Edward Silberman on 1528.

1691. Discussion of Proceedings Paper 1375, 1667. (PL) A. B. Wilder on 1375. Leon E. Brooks closure to 1375. James H. Dorough on 1667.

July

Journals: Engineering Mechanics, Structural, Surveying and Mapping, Sanitary.

1692. Cylindrical Bending of Elastic Plates, by S. J. Medwadowski and K. S. Pister. (EM) The effect of shear deformation on strong cylindrical bending of an elastic plate under uniform transverse load is considered. The problem is solved and graphs are given, from which numerical results are obtainable. The solution is compared with the corresponding result of the classical theory.

1693. Dynamic Elasto-Plastic Response of Rigid Frames, by Frank L. DiMaggio. (EM) Using expansions in terms of modes, the response of rigid frames to a concentrated force at the knee is determined. For two-hinged frames and a linearly decaying forcing function, two detailed numerical examples are presented. It is concluded that good approximations are obtained by considering only one elastic and one elastic-plastic mode.

1694. Design of Long Reinforced Concrete Columns, by Bengt Broms and Ivan M. Viest. (ST) A design procedure involving the strength of a short column, the eccentricity determined from an elastic analysis and a reduction coefficient is presented. The procedure may be used either at working or at ultimate load level.

1695. Structural Dynamics in Earthquake-Resistant Design, by John A. Blume. (ST) Strengths, rigidities, and ultimate earthquake resistances of traditional and modern buildings are compared. Research using four actual earthquake records provides shear values for 16 20-story "buildings" with various damping and stiffness characteristics.

1696. Earthquake Design Criteria For Stack-Like Structures, by John E. Rinne. (ST) This paper indicated the response of uniform and tapered stacks and stack-like structures to earthquake ground motion, develops some criteria for shears and moments for design, and compares these with criteria suggested or specified by others.

1697. Highway And Bridge Surveys: Preliminary Surveys, Progress Report of the Committee on Highway and Bridge Surveys. (SU) The preliminary survey for a highway is a detailed study of one or more feasible routes, resulting in a paper location which defines the line for the subsequent location survey. Mapping methods and critical factors affecting the selection of alignment are examined.

1698. Highway and Bridge Surveys: Location Survey, Progress Report of the Committee on Highway and Bridge Surveys. (SU) The location survey fixes the proposed highway's centerline on the ground and includes the procurement of field data necessary for complete design. Procedures for transferring the paper location to the ground are described as well as the manner of securing information on critical features of the location.

1699. Surveying for Richard I. Bong Air Force Base, by Peter A. Machinis. (SU) The surveying problems in the development of the Richard I. Bong Air Force Base although numerous were not of an unprecedented nature. Advance, coordinated planning based on a combination of new and old established surveying techniques produced the desired results.

1700. Photogrammetric Developments for Highway Engineering, by R. H. Sheik. (SU) Progress made in gaining the confidence of engineers and contractors in aerial photogrammetry can be maintained by the engineer and the aerial photogrammetric contractor insisting on accuracy.

1701. Gas Transfer To and From Aqueous Solutions, by Thomas R. Camp. (SA) This paper reviews the development of recent advances in the theory of gas transfer, with an examination of various items. Emphasis is put on the need for more research on the subject.

1702. Effects of Mechanics of Flow on Corrosion, by Amilcar J. Romeo, Rolf T. Skrinde, and Rolf Eliassen. (SA) This paper presents fundamental hydraulic concepts as applied to corrosion and the rate of interacting chemicals in flow over plates, rotating disks, and through pipes.

1703. Forced Circulation of Large Bodies of Water, by Thomas M. Riddick. (SA) In 1956 a floating aerator was put in service at the Ossining, N. Y. municipal water collecting reservoir. Results included completely breaking reservoir stratification, and oxidation and precipitation of iron and manganese, among others.

1704. An Introduction to Solar Distillation, by Tim de Jong. (SA) This paper presents a study and results of experiments on the production of potable water with solar energy on three pilot plants in Iran. Effects of geographical location, size and shape of plants, and descriptions of various plants and methods of distillation on the actual production of the pilot plants are explained with charts and tables.

1705. Sanitary Engineers: The Need and the Securing, by Frank A. Butrico and Mark D. Hollis. (SA) More, better, and differently qualified sanitary engineers are required. They should be attracted by a more adequate public relations campaign, and should be financially supported at the academic training levels especially in the undergraduate years.

1706. Limit Analysis of Simply Supported Circular Shell Roofs, by M. N. Fialkow. (EM) Plastic collapse of a partial circle cylindrical shell supported at each end with the longitudinal edges free is investigated for the case of uniform radial loading. The principles of limit analysis applicable to a plastic-rigid structure are utilized to develop upper and lower bounds for the collapse pressure.

1707. Wind Forces on Structures: Introduction and History, by J. M. Biggs. (ST) This paper is an introduction to a group of papers prepared by the Committee on Wind Forces of the Structural Division. The papers are Proceedings Papers 1707, 1708, 1709, 1710, 1711 and 1712.

1708. Wind Forces on Structures: Nature of the Wind, by Robert H. Sherlock. (ST) Recommendations are given for the one-minute-average wind velocity at a height of 30 feet as the basic velocity of reference in different parts of the country and for different height zones. The origin of strong winds, extra-tropical cyclones, hurricanes, and tornadoes are treated.

1709. Wind Forces on Structures: Fundamental Considerations, by Glenn B. Woodruff and John J. Kozak. (ST) This paper concerns forces on structures and structural elements caused by wind. The variables which determine magnitude of aerostatic and aerodynamic forces are examined. Pressure distribution and drag and lift coefficients for certain elementary shapes are shown.

1710. Wind Forces on Structures: Forces on Enclosed Structures, by Thomas W. Singell. (ST) This paper analyzes the work of past and present investigators and correlates data relating to shape coefficients for various building shapes. Included is a series of tables from the Swiss Building Code.

1711. Wind Forces on Structures: Plate Girders and Trusses, by W. Watters Pagon. (ST) This paper presents such

indications and conclusions as can be drawn at this time, of knowledge from available wind tunnel tests on plate girder and truss bridges, with open or closed deck, and for towers, antennae and similar structures.

1712. Wind Forces on Structures: Structures Subject to Oscillation, by F. B. Farquharson. (ST) Determination of wind forces on a structure is basically a dynamic problem. This paper is devoted to that portion of the problem involving structures which respond dynamically to the imposed wind forces.

1713. Highway and Bridge Surveys: Introduction to Bridge Surveys and Reconnaissance Survey, by Milton O. Schmidt, Chmn. (SU) The progressively longer span bridge structures now being built have made mandatory the use of accurate construction controls and use of geodetic equipment by trained personnel. Part B of the proposed manual deals with bridge surveys, and Chapter V describes the reconnaissance survey for a large bridge.

1714. Fringe Area Sewerage Problems, by John E. Kiker, Jr. (SA) The paper reviews the problems and some of the means of solving fringe area sewerage problems. The relative merits of septic tanks, package plants and oxidation ponds are considered from the standpoint of construction and operation.

1715. Design Details for Individual Sewage Disposal Systems, by Harrison A. Martin. (SA) Design procedures, simplification of design methods and comment on design of septic tank systems are presented. Some standardization is provided and methods are examined.

1716. Precise Surveys for Mackinac Bridge, by R. M. Boynton. (SU) A description is given of surveying problems involved, equipment and methods used to establish a major triangulation net on land, and vertical control across approximately four miles of water.

1717. Controlled Submergence of Pittsburgh's Deep Sewers, by J. F. Laboon. (SA) Design features of Pittsburgh's thirty miles of tunnel sewers now under construction by the Allegheny County Sanitary Authority, and proposed procedures for operation of the system under controlled submergence are described in this paper.

1718. Effective Width of Thin Rectangular Plates, by Morris Ojalvo and Frederick H. Hull. (EM) The behavior of simply supported rectangular plates subjected to edge compression in one direction is investigated by means of load-shortening tests. The data are presented by non-dimensional curves of effective width versus average unit shortening.

1719. Bending of Elastically Supported Rectangular Plates, by Melvin Zaid and Marvin Forray. (EM) The problem of bending of a rectangular plate, elastically supported on variable rigidity beams, subjected to a transverse loading or temperature gradient is solved in this paper. Specific combinations of support are examined, and a detailed solution is given for a square plate with one edge free.

1720. Education in Surveying and Photogrammetry in Europe, by G. Gracie and H. Karara. (SU) This paper presents the formal education in surveying and photogrammetry offered in a number of western European countries. The various university undergraduate courses in surveying and photogrammetry and the graduate studies and degrees are examined.

1721. Discussion of Proceedings Papers 1023, 1302, 1304, 1440, 1510, 1519, 1567. (ST) A. W. Hendry and L. G. Jaeger closure to 1023. Stewart Mitchell and Gerald F. Borrmann closure to 1302. Carl E. Ekberg, Jr., Rene E. Walther, and R. G. Slutter closure to 1304. John M. Hayes corrections to 1440. J. J. Hromadik on 1510. W. J. Jurkovich on 1519. Harry Posner corrections to 1567. William S. Walker and Joseph T. Kolibal on 1567.

1722. Analysis of Finite Beams on Elastic Foundation, by Denos C. Gazis. (ST) The analysis of bending of finite beams on elastic foundation, under the action of an arbitrary distribution of lateral loads, is accomplished by an iterative procedure analogous to the Hardy Cross method for the analysis of continuous beams and structural frames.

1723. The Behavior of One-Story Brick Shear Walls, by Jack R. Benjamin and Harry A. Williams. (ST) This paper gives the results of an investigation of the effectiveness of unreinforced brick masonry walls to resist shear forces applied in the plane of the wall. Some approxi-

mate relationships are suggested as a means of predicting the behavior of such walls.

1724. Discussion of Proceedings Papers 1604. (EM) A. Hrennikoff corrections to 1604.

AUGUST

Journals: Hydraulics, Power, Soil Mechanics and Foundations.

1725. Outlet Structures for Fixed-Dispersion Cone Valves, by Maurice L. Dickinson, Stanley M. Barnes and Robert S. Milmoe. (HY) Outlet structures housing fixed-dispersion cone valves at three locations with varying requirements for protection against freezing, energy dissipation, and dependable remote control with close regulation of discharge are described. Results of model and prototype tests are given.

1726. Hurricane Protection Planning in New England, by John B. McAleer and George E. Townsend. (HY) Hurricane Carol of August, 1954, triggered authorization of a hurricane survey of the Atlantic and Gulf Coasts. This paper describes the basic data and engineering methods used in the New England area.

1727. Predicting Seepage Under Dams on Multi-Layered Foundations, by Paul H. Shea and Harry E. Whitsett. (SM) This paper presents methods developed for predicting rates of seepage under dams and levees on multi-layered foundations. A description of the pumping test procedure used to implement those methods is included.

1728. Design and Performance of Vermillion Dam, by K. Terzaghi and T. M. Leps. (SM) Design and performance of a zoned earth dam on marginal glacial deposits is described. The deposits were so intricately stratified that determination of essential geological features had to be deferred until the construction period.

1729. Procedure for Rapid Consolidation Test, by Hsuan-Loh Su. (SM) A method for the consolidation test is given with precision of results comparable to that from a conventional test.

1730. Effects of Ground on Destructiveness of Large Earthquakes, by C. Martin Duke. (SM) Knowledge of the relation between ground conditions and earthquake damage to structures is presented in terms of observations of destructive earthquakes. Thirty-six earthquakes are cited for which a relation has been reported.

1731. Pressure Grouting Fine Fissures, by Thomas B. Kennedy. (SM) Fine horizontal cracks between concrete slabs were grouted in a laboratory study. It was found that certain materials, when added to grouts, greatly reduced their solubility.

1732. Geotechnical Properties of Glacial Lake Clays, by T. H. Wu. (SM) This paper describes properties of glacial lake clays. Data collected from the Great Lakes are are presented. The investigation consists of an evaluation of the stress history and structure of the clay deposits.

1733. Rockfill Dams: Cherry Valley Central Core Dam, by H. E. Lloyd. O. L. Moore and W. F. Getts. (PO) Construction and performance of the Cherry Valley Dam of the Hetch Hetchy Water Supply of the City and County of San Francisco is described. Measurements of the settlements and deflections are given.

1734. Rockfill Dams: Brownlee Sloping Core Dam, by Torald Mundal. (PO) This paper describes the design and construction of the rock-fill dam portion of Brownlee Hydroelectric Project, including diversion of flood waters over the partially completed embankment, and construction of the embankment on 110 feet of river-deposited materials.

1735. Rockfill Dams: Kajakai Central Core Dam, Afghanistan, by Glenn F. Sudman. (PO) This paper examines the design and construction of the rockfill dam embankment portion of Kajakai Project, that required maximum use of locally obtainable materials and training of a native work force.

1736. Rockfill Dams: Performance of TVA Central Core Dams, by George K. Leonard and Oliver H. Raine. (PO) Presented is a comparison between design assumptions that may influence that design of rockfill dams. Three TVA rockfill dams are considered in this light.

1737. Rockfill Dams: Salt Springs and Lower Bear River Concrete Face Dams, by I. C. Steel and J. B. Cooke. (PO) The 28-year service record of Salt Springs Dam is presented. The design, construction and performance of the two Lower Bear River Dams is presented and compared to that of Salt Springs Dam.

1738. Rockfill Dams: The Dalles Closure Dam, by Robert J. Pope. (PO) The problem of a closure dam for the Dalles project in 180-foot depth of water was solved by the design and construction of a rockfill structure, two-thirds of which was built under water.

1739. Rockfill Dams: Review and Statistics, by John B. Snethlage, F. W. Scheidenhelm and Arthur N. Vanderlip. (PO) The paper reviews present practices on rockfill dams and develops a definition, classification and terminology for such dams and for those using earth in addition to rock fill. Advantages of deck-type dams and settlement and economy of rockfill dams are examined.

1740. Rockfill Dams: The Bersimis Sloping Core Dams, by F. W. Patterson and D. H. MacDonald. (PO) The Bersimis No. 1 hydroelectric power development in Canada involved the construction of two earthfill dams and two rockfill dams. This paper describes the site, design, construction, and performance of these dams.

1741. Rockfill Dams: The Derbendi Khan Dam, by Calvin V. Davis. (PO) Problems in designing a central core rockfill dam in Iraq are described. A field exploration and materials testing program provided a sound basis for the selection and design of the dam.

1742. Rockfill Dams: Nantahala Sloping Core Dams, by James P. Growdon. (PO) Design of a 250-foot high sloping core rockfill dam was determined to facilitate construction with materials readily available. This paper describes the site and examines construction procdures and performance.

1743. Rockfill Dams: Dams With Sloping Earth Cores, by James P. Growdon. (PO) This paper reviews the principles which govern the design of a rockfill dam and examines six rockfill dams.

1744. Rockfill Dams: Performance of Seven Sloping Core Dams, by James P. Crowdon. (PO) Design and construction of seven dams is briefly reviewed. Performance, measured in terms of leakage, repairs and maintenance is presented.

1745. Rockfill Dams: Performance of Mud Mountain Dam, by Allen S. Cary. (PO) Mud Mountain Dam, an earth and rockfill structure 400 feet high, has settled in the core zone as predicted during design studies based on large scale consolidation tests. Results of settlement are given.

1746. Rockfill Dams: Wishon and Courtright Concrete Face Dams, by Barry Cooke. (PO) Design and construction of two approximately 300-foot high dams are discussed. Changes in design and construction from previous P. G. and E. dams have been made to lower the cost without affecting safety.

1747. Rockfill Dams: The Paradela Concrete Face Dam, by Luis Henreque Gomes Fernandes, Edgard de Oliveira and Nuno de Vasconcelas Porto. (PO) The 361-foot high dam forms part of the hydro-power development of orthern Portugal. The paper discusses the selection of site, type of dam, procedure, design and construction details. Performance data is given.

1748. Rockfill Dams: The Paradela Dam—Foundation Treatment, by Walter J. Weyermann. (PO) Foundation conditions at the site of the Paradela Dam in Portugal and the various problems presented are described. This paper examines the arrangement of grout curtains and presents performance data on seepage control.

1749. Rockfill Dams: Design of Cougar Central Core Dam, by Paul Thurber. (PO) A central-core section was decided for Cougar Dam. The susceptibility of a sloping core of compacted earth to rupture from the type of settlement that would occur helped in making the choice.

September

Journals: Irrigation and Drainage, Structural, Waterways and Harbors, Sanitary.

1750. Potential Use of Water by Irrigation in the Humid Areas, by Keith H. Beauchamp. (IR) This paper examines the problems of increasing irrigation water demands. Aspects of humid area irrigation offsetting uneven rainfall distribution and stabilizing production and income are presented.

1751. Worldwide View of Irrigation Developments, by N. D. Gulhati. (IR) The development of water resources to provide irrigation facilities, improve existing agriculture, and to reclaim large areas of desert or otherwise barren lands are presented.

1752. Multiple-Use Projects in Development of Water Resources, by W. A. Dexheimer. (IR) Doubling the United States present water supply by 1975 requires cooperative and multiple-purpose planning. River-basin construction should be coordinated by local, state, and federal agencies.

1753. State Versus Federal Control of Western Waters, by Lewis A. Stanley. (IR) Examined in this paper is the Supreme Court decision in the Pelton Dam case as it affects the sovereignty of the western states in the control of nonnavigable waters within their borders.

1754. Water—A Limiting Resource? by Robert O. Thomas. (IR) This paper emphasizes the magnitude of the anticipated demand for water in the United States. The availability of water is compared with the major demands made upon the supply.

1755. Thermal Considerations in the Design of Concrete Shields, by Harold S. Davis. (ST) Behavior and properties of concrete structures for shielding atomic power plants are presented, with methods for estimating thermal effects associated with linear and non-linear distribution of temperature, nuclear heating, and shield cooling.

1756. An Analytical and Experimental Study of Helicoidal Girders, by Y. F. Young and A. C. Scordelis. (ST) A study of the helicoidal girder, fixed at the ends, subtending a horizontal angle of 180°, and having a slope of 30° is presented.

1757. Practical Aspects of Ultimate Strength Design, by Alfred L. Parme. (ST) Time-saving design charts for the rapid selection of the critical load factor combination are presented. Loads and area of reinforcement obtained by ultimate strength design procedure are compared with those obtained by conventional methods.

1758. Numerical Analysis of Two-Hinged Arches, by Thomas D. Y. Fok and Tung Au. (ST) This paper presents a numerical solution for the influence ordinates of the horizontal reaction in a two-hinged arch of variable section.

1759. High-Speed Computer Applied to Bridge Impact, by Charles T. G. Looney. (ST) Results of a study of the impact on highway bridges is described. The effect of different bridge and truck characteristics are presented, and also a dimensionless representation of all the variables.

1760. Causes of Deterioration and Protection Methods: Progress Report of a Sub-Committee of the Committee on Timber Structures. (ST) The causes of deterioration of wood and the conditions under which damages result are described. General methods in use for protection of timber structures are given.

1761. Analysis of Rigid Frames by Successive Replacement, by Chen Loh-Kwan and Li Seung Ping. (ST) An analytical method is developed for the calculation of moments at the supports or joints of rigid frames by replacing a portion of a structure with a member of its equivalent in stiffness or in rigidity.

1762. Analysis of Continuous Beams by Carry-Over Moments, by Jan J. Tuma. (ST) A general method for the analysis of continuous beams of constant or variable depth is presented and tables are given.

1763. General Considerations for Reactors and Related Plant Types, by John F. Stolz. (ST) This paper classifies reactors according to their purpose and examines those reactor plants designed for power generation.

1764. Analysis of Frames with Curved and Bent Members, by Jan J. Tuma, Kerry S. Havner and Frank Hedges. (ST) The application of a modified moment distribution method to the analysis of continuous and complex frames with curved and bent members is presented.

1765. Laboratory Studies of Wind Waves in Shallow Water, by John C. Hufft. (WW) This paper presents the results of a laboratory investigation of the growth of wind waves in relatively shallow water, including experimental relationships between velocity, fetch, and wave parameters for two different water depths.

1766. Irrawaddy River System of Burma, by Henry R. Norman. (WW) This paper examines transportation conditions of the Irrawaddy River system of Burma up to 1953, including the pre-war, wartime, and the post-war system.

1767. Model Studies of Sector Gate Type Locks, by Frederick R. Brown. (WW) Sector gate type locks may be used to advantage where reverse head conditions are encountered or where it is desirable to operate the gates under head for passage of debris or ice. Results of model tests are given.

1768. The Port of Chicago, by Austin E. Brant, Jr. (WW) This paper presents the results of a detailed economic and engineering study of the port of Chicago and the effects on the Port of the St. Lawrence Seaway.

1769. Changing Site Requirements for Port Operation, by Peter Engelmann. (WW) Changes in cargo handling methods at modern ports are analyzed, concluding that, for maximum future operating efficiency, dock-side transit areas should be greatly enlarged.

1770. The Suez Canal—Its Chronicle and Bibliography, by Shu-t'ien Li. (WW) The chronicle of development and engineering events of the Suez Canal beginning 4,000 years ago to 1956, and a bibliography of all published works from 1800 to 1957 are presented.

1771. The American Locks of the St. Lawrence Seaway, by John P. Davis. (WW) Design and construction of the Eisenhower and Grass River locks of the St. Lawrence Seaway are described, and the necessity for and design of certain measures required for damage control is stressed.

1772. Scientific Developments in River Transportation, by C. R. Horton, Jr. (WW) The paper describes progress made in model testing of push-type river towboats and barge fleets. Progress in improving efficiency of river towboats by the new model techniques is evaluated in terms of performance and economics.

1773. Hydraulic Design of Columbia River Basin Navigation Locks, by G. C. Richardson and N. J. Webster. (WW) This paper presents design aspects of the hydraulic systems of the Columbia River Basin's lift navigation locks.

1774. Land Subsidence due to Ground-Water Development, by J. F. Poland. (IR) Land subsidence has occurred in several areas of intensive ground-water development in California. This paper examines the subsidence areas, and summarizes the principal problems that have developed.

1775. The Engineer and Worldwide Conservation of Soil and Water, by Orson W. Israelsen. (IR) The role of the engineer in worldwide soil and water conservation is emphasized. A report on drainage systems and irrigation projects is presented.

1776. Simplified Techniques in Air Pollution Measurement, by E. R. Hendrickson. (SA) Reviewed are several applications of simplified techniques in air pollution measurements and the needs involved in setting up an air pollution sampling program.

1777. Proposed Changes in Eastern Water Use Policies, by Murray Stein. (SA) This paper considers and compares changing uses of water in the east with western state uses. Consideration is given to the work to be done on a "Model Water Use Act."

1778. Design of Chicago's Central Filtration Plant, by Fred G. Gordon. (SA) This paper consists of a general review of the design features of the Central District Filtration Plant of Chicago.

1779. SED Research Report No. 20: Bottom Deposits in a River and their Potential Effects on Dissolved Oxygen Concentration. (SA) The effect of organic bottom deposits indicates reduction of dissolved oxygen concentration in flowing water. The paper uses a part of the Connecticut River to demonstrate the importance of evaluating bottom deposits in studying pollution.

1780. Resistance of Sewage Sludge to Flow in Pipes, by Tsung-Lien Chou. (SA) Flow of sewage sludge in pipes is classified into four categories of different characteristics and criterion and practical formulas are developed.

1781. The Beauharnois Canal Locks, by Duncan McIntyre. (WW) The Beauharnois locks on the St. Lawrence Seaway are described. The selection of the locking arrangements are presented, along with construction features of the locks.

1782. Planning the Future for Chicago's Water System, by W. W. De Berard. (SA) In 1953 the operating functions of the Chicago water system were placed under the Bureau of Water. Chicago is now eliminating possibilities of water shortages, and arrangements are being made to furnish water from the Lake Michigan source to suburban communities.

1783. Capacity Criteria for Refuse Incineration, by Samuel M. Clarke. (SA) Changes in accepted methods of stating refuse incinerating capacities are proposed to distinguish plant capacity from furnace capacity. The importance of the class of refuse to be burned is stressed, and design criteria, based on BYU loadings are suggested.

1784. Discussion of Proceedings Paper 1352, 1360, 1362, 1363, 1364, 1497, 1501, 1507, 1589, 1591. (IR) E. A. Kimbrough, Jr., closure to 1352. Isidro D. Carino closure to 1360. Charles W. Thomas closure to 1362. Clyde P. Cass, Jr., and Richard T. Shen on 1363. Louis W. Herndon closure to 1363. Frederick L. Hotes on 1364. Ray L. Derby closure to 1364. Alfred R. Golze on 1497. J. Ernest Flack on 1501. Harry F. Blaney on 1507. Frederick L. Hotes on 1589. Frederick L. Hotes on 1591.

1785. Discussion of Proceedings Paper 1366, 1569, 1644. (WW) E. M. Cummings closure to 1366. John B. Herbich on 1569. Robert E. Hickson on 1644.

1786. Discussion of Proceedings Paper 1534, 1608. (SA) Charles H. Lawrance and David R. Miller, D. I. H. Barr on 1534. M. B. McPherson and J. V. Radziul on 1608.

1787. Discussion of Proceedings Paper 1303, 1318, 1357, 1431, 1434, 1510, 1519, 1561, 1562, 1563, 1567, 1633, 1637, 1711. (ST) A. M. Lount closure to 1303. Leroy T. Oehler closure to 1318. Frank Baron closure to 1357. Nan-Sze Sih closure to 1431. Richard Z. Zimmermann closure to 1434. T. Jumikis and A. S. Hall on 1510. Charles D. Susman on 1519. Marvin A. Larson, Giles G. Green, Bruce G. Johnston, A. Chibaro on 1561. Alexander Dodge, Lymon C. Reese on 1562. A. A. Eremin on 1563. A. A. Eremin on 1567. Fritz Leonhardt on 1633. W. H. O'Brien on 1637. Corrections to 1711.

1788. The Importance of Hydraulics of Surface Irrigation, by Vaughn E. Hansen. (IR) Hydraulic elements involved in surface irrigation are listed and examined. Relating these hydraulic elements is the key to efficient irrigation, good design, and a permanent agriculture.

1789. Navigation on the Columbia River, by Ray E. Holmes. (WW) This paper presents the historical development of navigation of the Columbia River, including a description of navigational structures, maintenance procedures, past and present, and an examination of possible trends.

October

Journals: Structural, Hydraulics, Soil Mechanics and Foundations, Engineering Mechanics, Highway, Power.

1790. Minimum Weight of Frames Under Shakedown Loading, by Jacques Heyman. (EM) This paper examines the minimum weight design of framed structures under both fixed and independently varying loads. A numerical example is given, for which the solution is obtained, and the results corresponding to the two types of loading are compared.

1791. Effect of End-Fixity on the Vibration of Rods, by D. Burgreen. (EM) A study is made of the free vibration of rods with end supports of equal elasticity. Expressions are derived relating the end-fixity to frequency and mode of vibration. With the proper type of negative springs attached to the ends of the rod, it is shown that vibrations can be surpressed.

1792. Eccentrically-Loaded, Hinged Steel Columns, by R. E. Mason, G. P. Fisher and Geo. Winter. (EM) Tests are reported on thirty eccentrically and concentrically loaded steel columns. Failure loads are compared with predictions by the secant formula and other current methods.

1793. Approximate Buckling Loads of Open Columns, by Yu-kweng M. Lin. (EM) A general equation applicable to any boundary conditions for coupled buckling of thin-walled open columns is presented. It is found that a most general problem of triple coupling may be solved approximately as two double coupling cases.

1794. Dynamic Effect of a Moving Load on a Rigid Frame, by R. C. De Hart. (EM) The dynamic effect of a distributed load moving with constant velocity across a rigid frame is described in this paper. It is demonstrated that a single impact factor is not applicable to all parts of the frame.

1795. The Research Phase of the AASHO Road Test, by W. N. Carey, Jr. (HW) In this report the principles underlying the experiment design for the AASHO Road Test are examined along with the basic analyses that will be performed. The principal dependent variable is defined and the independent design variables are listed.

1796. The History of Road Tests, by E. A. Finney. (HW) This report traces the construction of different types of road tests in the United States from the latter part of the 18th century to the AASHO Road Test now under construction in the State of Illinois.

1797. Creating a Better Understanding of Traffic Engineering, by Donald M. McNeil. (HW) The increasing use of private motor vehicles has necessitated the specialization known as Traffic Engineering. This phase of engineering deals with the planning of streets, highways, abutting lands, and with traffic operation thereon.

1798. The AASHO Road Test, by W. B. McKendrick, Jr. (HW) The AASHO Road Test at Ottawa, Illinois is sponsored by the American Association of State Highway Officials. This paper outlines objectives and purposes, administrative procedures, financing, and progress of the construction of the test facility.

1799. Reinforcement in Continuous Concrete Pavements, by Vedat A. Yerlici. (HW) An analytical approach to a national design method is presented for the reinforcing steel in continuous concrete highway pavements. Formulas are derived, giving needed steel area and perimeter to insure against widening of cracks in the slab.

1800. Tests of Concrete Pavements on Gravel Subbases, by L. D. Childs and J. W. Kapernick. (HW) This paper examines the effect of subbase thickness on pavement performance, concluding that a greater load capacity can be achieved by thickening the concrete rather than by building deep subbases.

1801. Urban Transportation Problem: Progress Report of the Committee on Urban Transportation of the Highway Division. (HW) Cities must achieve a rational balance between essential modes of transportation, and the modern urban complex demands an areawide approach to the problem. Transportation planning must be more closely integrated with economic, sociological and political factors.

1802. Needs Studies on a Continuing Basis, by R. E. Livingston. (HW) This paper outlines the necessity for a standard procedure for preparing cost estimates used in needs studies of highway systems. It considers elements of the estimate and the work items comprising them.

1803. Comprehensive Transportation Planning, by R. I. Creighton. (HW) Systematic methods are described for analyzing data and preparing and testing plans for all types of transportation facilities in urban areas, based on forecasts of traffic as generated by future land uses.

1804. Need of the Interstate System of Highways, by G. M. Williams. (HW) Provisions of the Federal-Aid Highway Acts from 1916 through 1956, the actions leading to establishment of the Interstate System of Highways in 1944, and the plans for accelerating the rate of construction are reviewed.

1805. The Federal Highway Program in New York State, by John W. Johnson. (HW) This paper examines the efforts of, the federal and state governments in the building of the nation's highways from 1916 to the present day. A synopsis is developed of New York State's multi-billion dollar construction program with illustrative comments on area alignments.

1806. Sedimentation Studies in the Western Gulf States, by Graham W. Renfro and Charlie M. Moore. (HY) A summary of the more important reservoir sedimentation surveys made by the Soil Conservation Service in the area is presented. Methods used in determining sediment yields are described. The effect of watershed protection measures, including floodwater retarding structures in reducing sediment yield from watershed is examined.

1807. Some Experiments with Emergency Siphon Spillways, by Warren B. McBirney. (HY) Two model designs of low head siphon spillways were tested. Operational characteristics and peculiarities of the two siphon designs are discussed and supporting data and pictures are included.

1808. Synthetic Flood Frequency, by Franklin F. Snyder. (HY) A procedure is developed for computing the flood discharge probability associated with a given rainfall-duration-frequency pattern on natural drainage basins, nonchannelized overland flow areas and areas with storm sewer drainage.

1809. Divining Rods Versus Hydrologic Data and Research, by W. B. Langbein. (HY) The divining rod as a mystical hydrologic decision-maker is contrasted with modern basic-data programs. The extent and kinds of gaps in basic data are discussed with emphasis on deficiencies in research and interpretation.

1810. Numerical Solution of Flow Problems in Rivers, by E. Isaacson, J. J. Stoker and A. Troesch. (HY) New methods for dealing with flow problems in large rivers and reservoirs for lengthy periods of time are developed. The simplicity and flexibility of the methods are explained.

1811. Queuing Theory and Water Storage, by W. B. Langbein. (HY) A method for determining the amount of holdover storage for regulating streamflow is presented based on analogies with queues. Where discharge varies linearly with reservoir contents a unique expression is derived. The queuing analogy leads to a general solution by "probability routing."

1812. Analysis for Partially Penetrating Sand Drains, by E. G. Hart, R. L. Kondner, and W. C. Boyer. (SM) A numerical procedure of analysis for partially penetrating sand drains has been developed. Possible simplified methods of analysis are indicated and laboratory tests have been conducted to correlate these methods with observed rates of consolidation.

1813. Grouting Deep Solution Channels Under an Earth Fill Dam, by Leland F. Grant and Lewis A. Schmidt. (SM) Deep limestone solution channels caused leakage under an elliptical earth fill dam which forms a pond for log storage at Bowaters Southern Paper Corporation's newsprint mill at Calhoun, Tennessee. The foundation was stabilized by grouting and leakage was eliminated successfully.

1814. Digital Computation for Stiffness Matrix Analysis, by J. S. Archer. (ST) A matrix

method is described for the static stress and normal mode analysis of highly indeterminate structures on large scale digital computers. This method is applied to the analysis of basic types of civil engineering structures.

1815. Numerical Solutions for Interconnected Bridge Girders, by Henry Malter. (ST) Two numerical methods for the solution of the problem of interconnected bridge girders are considered for the particular case involving infinite tortional rigidity of the main longitudinal members for two-girder and four-girder structures.

1816. Generalization of the Successive Approximations Method, by Panagiotis D. Moliotis. (ST) This paper presents the theory and the methods of analysis of rigid frames whose joints are not points but are considered as small undeformed areas. These frames are analyzed by the method of successive approximations and examples are presented.

1817. Golden Gate Bridge Vibration Studies, by George S. Vincent. (ST) Presented are the results of observations of the movements of the Golden Gate Bridge. Correlations with theoretical calculations of wave forms and wind tunnel tests indications of the behavior to be expected of the bridge are made.

1818. Concrete Beams and Columns With Bundled Reinforcement, by N. W. Hanson and Hans Reiffenstuhl. (ST) Tests of pairs of large beams with conventionally spaced and with bundled longitudinal reinforcement are reported. No significant difference in behavior or strength was found for bundled as compared to spaced reinforcement.

1819. Matric Formulation of Slope-Deflection Equations, by Chu-Kia Wang. (ST) A simple and systematic way is outlined so that slope-deflection equations may be put in matric form. This method will expedite the exact analysis of many complex rigid frames under many loading conditions, including sideways.

1820. Deflection of Variable Stiffness Members, by D. G. Fertis and E. C. Zobel. (ST) This paper determines deflection of members with variable stiffness by selecting a reference value and by replacing a member with an equivalent system having a uniform stiffness.

1821. Amplification of Stress and Displacement in Guyed Towers, by Robert S. Rowe. (ST) Problems dealing with the amplification of stress and displacement in guyed towers when changes in geometry are included in the analysis are presented. A simplified method for determining the slack stress in the guy and horizontal displacements due to wind load are also considered.

1822. Large Deflection of Elasto-Plastic Plates Under Uniform Pressure, by Thein Wah. (EM) The differential equation for the deflection of an infinitely long plate is well known. In this paper the analysis is carried into the plastic range for the case of uniform and clamped edges.

1823. The Pelton Hydro-Electric Development, by J. M. Mullarkey. (PO) A description of the project, of the design of the dam and spillway, and of the construction plant and progress is given in this paper.

1824. Computation of the Stability of Slopes, by Otto H. Meyer. (SM) This paper develops analytical formulas for the solution of problems involving the stability of earth slopes and embankments, and included graphs making it possible to solve these problems with a minimum of computations.

1825. Consolidated C.B.R. Criteria, by R. G. Ahlvin. (SM) Flexible pavement design criteria as used by the Corps of Engineers are reduced to a single plot and compared with all available service-behavior-type data. The data, which include test section and documented in-service results, are tabulated.

1826. Progress Report on Glossary of Terms and Definitions in Soil Mechanics. (SM) This report, prepared by the ASCE Committee on Glossary of Terms and Definitions in Soil Mechanics presents a compilation of terms, definitions and symbols currently in use in soil mechanics literature.

1827. Discussion of Proceedings Paper 1436, 1437, 1509, 1560, 1562, 1633. (ST) Per Hall, Troels Bromdun-Nielsen and H. R. Kivisild closure to 1436. Alan M. C. Holmes closure to 1437. Juergen Plaehn on 1509. Corrections to 1509. I. M. Nelidov on 1560. Victor R. Bergman and N. J. Ryker, Jr. on 1562. A. Kabaila on 1633.

1828. Discussion of Proceedings Paper 1309, 1427, 1428, 1429, 1535, 1537, 1545, 1546, 1547, 1548, 1549, 1550 1552, 1654, 1655. (SM) R. W. Johnson closure to 1309. H. B. Seed and C. K. Chan closure to 1427. K. S. Bawa closure to 1428. Gunnar M. Brune closure to 1429. Lymon C. Reese and Hudson Matlock, John A. Focht on 1535. D. C. Pearce corrections to discussion 1657. Bruce E. Clark on 1545. Bruce E. Clark on 1546. Bruce E. Clark on 1547. Bruce E. Clark and L. A. Schmidt, Jr. on 1548. Bruce E. Clark on 1549. Bruce E. Clark on 1550. L. A. Schmidt, Jr. on 1552. B. P. Warkentin and R. N. Y. Yong and G A. Leonards on 1654. Alfred C. Scheer, R. N. Y. Yong and P. B. Warkentin on 1655.

1829. Discussion of Proceedings Paper 1372, 1374, 1626, 1627. (HW) Alfred C. Scheer closure to 1372. Joseph Barnett closure to 1374.

Wilson Davis and Lewis H. Tuthill on 1626. Stephen G. Petersen on 1627.

1830. Discussion of Proceedings Paper 1330, 1398, 1414, 1420, 1488, 1598. (PO) J. Barry Cooke and Arthur G. Strassburger closure to 1330. E. L. Seeland closure to 1398. Howard A. Preston, and Louis E. Rydell closure to 1414. Sylvan J. Skinner closure to 1420. R. T. Richards closure to 1488. F. C. Rodriguez, Stavros N. Nicolaou on 1598.

1831. Discussion of Proceedings Paper 1390, 1399, 1496, 1596, 1604, 1706. (EM) H. M. Nelson, D. T. Wright and J. W. Dolphin closure to 1390. Seng-Lip Lee closure to 1399. Corrections to 1496. Corrections to 1596. Keith Jones on 1604. Corrections to 1706.

1832. Discussions of Proceedings Papers 1197, 1201, 1260, 1264, 1266, 1331, 1345, 1393, 1395, 1401, 1402, 1403, 1405, 1401-1406, 1401 and 1405, 1406. (HY) John L. Bogardi on 1197. Closure to 1197. W. G. Whippen and G. D. Johnson closure to 1201. Ahmed Shukry closure to 1260. R. H. Berryhill closure to 1264. M. B. McPherson and M. H. Karr closure to 1266. Walter C. Carey and M. Dean Keller closure to 1331. P. K. Kandaswamy and Hunter Rouse closure to 1345. F. Paderi on 1345. J. M. Robertson and G. L. Calehuff closure to 1393. E. Kuiper closure to 1395. J. N. Bradley and A. J. Peterka closure to 1401. J. N. Bradley and A. J. Peterka closure to 1402. J. N. Bradley and A. J. Peterka closure to 1403 J. N. Bradley and A. J. Peterka closure to 1406. J. N. Bradley and A. J. Peterka closure to 1401-1406. Corrections to discussion to 1616. J. N. Bradley and A. J. Peterka closure to 1401 and 1405.

NOVEMBER

JOURNALS: Hydraulics, Sanitary Engineering, Structural, Surveying and Mapping.

1833. WAVE FORCES ON SUBMERGED STRUCTURES, BY ERNEST F. BRATER, JOHN S. McNOWN AND LESLIE D. STAIR. (HY) The magnitude and characteristics of forces resulting from oscillatory waves were determined for models of submerged barge-like structures.

1834. SNOWMELT RUNOFF, BY J. HAROLD ZOLLER AND ARNO T. LENZ. (HY) Factors relating to the melting of snow were evaluated for the snowmelt periods of 1938 through 1952 for the Big Eau Pleine River in Wisconsin. Convection and condensation melt potentials were computed from equations developed by previous investigations.

1835. HYDROLOGICAL ASPECTS OF RADIOACTIVE WASTE DISPOSAL, BY WILLIAM H. BIERSCHENK. (SA) Geologic and hydrologic data have made it possible to predict the behavior of low-level radioactive wastes. At no time in the plant's history has the undergound movement of radioactive wastes resulted in detectable amounts reaching points of public access.

1836. BLAST PHENOMENA FROM A NUCLEAR BURST, BY FERD. E. ANDERSON, JR. (ST) This paper describes the air blast and ground shock free field phenomena associated with a nuclear burst. The data presented extend that presented in the publication, "The Effects of Nuclear Weapons."

1837. BLAST LOADING STRUCTURES, BY H. L. MURPHY. (ST) An examination of blast loading on structures is presented in terms of nuclear blast phenomena and is related to closed rectangular structures located above ground, semi-buried, and underground.

1838. THE FACTOR OF SAFETY IN DESIGN OF TIMBER STRUCTURES, BY LYMAN W. WOOD. (ST) Reduction in the average strength of clear wood is made necessary by the conditions of structural use. A way to estimate safety is to use near minimum values for these conversion factors and make a further reduction for unforseen conditions.

1839. LIGHT WOOD TRUSSES, BY R. F. LUXFORD. (ST) Strength tests were made on trusses with spans ranging from 17 to 32 feet, and with slopes from 5 in. 12 to 1 in. 1_2. It was found that glued trusses are stronger and stiffer than nailed trusses.

1840. GLUED LAMINATED WOOD CONSTRUCTIONS IN EUROPE, BY M. L. SELBO AND A. C. KNAUSS (ST) History and current status of wood laminating industry is reviewed. Adhesives, wood species and production methods are compared with U.S.A. practices.

PERMANENT STRUCTURES, BY C. MILES

1841. PRESSURE PRESERVED WOOD FOR BURPEE. (ST) This paper explains how modern science has developed preservatives that insure long service, how the evaluation of soil investigations can lead to the design of more economical foundations, and why pole-type buildings are becoming popular for industrial and commercial uses.

1842. HIGHWAY AND BRIDGE SURVEYS: PRELIMINARY BRIDGE SURVEYS, PROGRESS REPORT OF THE COMMITTEE ON HIGHWAY AND BRIDGE SURVEYS OF THE SURVEYING AND MAPPING DIVISION. (SU) This paper treats the details of conducting the surface and hydrographic surveys for long-span bridges over water and examines the requirements of the Geological and Foundation Survey.

1843. CHARTS FOR THE AIR FORCE, BY RICHARD W. PHILBRICK. (SU) Charts for the United States Air Force are published by the Aeronautical Chart and Information Center. The latest photogrammetric and cartographic techniques are used. About one hundred million charts a year are distributed throughout the world.

1844. THE STATE RESPONSIBILITY TOWARDS SURVEYING AND MAPPING, BY BURTON R. INGALLS. (SU) The state has a responsibility for an adequate surveying and mapping program. There is a need for a new type of service. A new type of state agency can provide this.

1845. THE ILLINOIS AND MICHIGAN CANAL STATE PROPERTY SURVEY, BY CHARLES D. MITCHELL. (SU) This paper gives the history of the Illinois and Michigan Canal and the present day problem of re-establishing the boundary lines with those made upon completion of the Canal in 1847-1848.

1846. PHOTOGRAMMETRY AIDS IN PIPELINE LOCATION SURVEYS, BY ALFRED O. QUINN. (SU) New techniques make photogrammetry an invaluable aid to pipeline location engineers. Combined use of aerial photography, topographic maps, and detailed studies of terrain helps to select feasible routes at minimum time and expense. Integrated photogrammetric programs provide the necessary basic surveying and mapping data.

1847. SLEUTHING THE BEHAVIOR OF A RIVER, BY EDWARD J. CLEARY. (SA) Seven years ago the Ohio River Valley Water Sanitation Commission instituted a program for systematic surveillance and appraisal of quality conditions and flow variations. The program is described in detail.

1848. FORESTS AND WATER YIELD, BY NEDAVIA BETHLAHMY. (SA) The paper reviews the problems involved in the yield of water from forest areas.

1849. ANAEROBIC CONTACT PROCESS FOR TREATMENT OF SUBURBAN SEWAGE, BY J. L. WITHEROW, J. B. COULTER AND M. B. ETTINGER. (SA) Pilot plant studies are described on an anaerobic contact process incorporating simplicity of design and absence of moving parts for treatment of domestic sewage. The process which produces an effluent low in B.O.D. and suspended solids is being developed for small groups of houses.

1850. AN ANALOG COMPUTER FOR THE OXYGEN SAG CURVE, BY MORTON D. SINKOFF, C. DON GEILKER, AND JAN G. RENNERFELT. (SA) The theory of an electrical analogy to the Streeter-Phelps oxygen sag equation is described. The analogy is applied in the construction of an instrument for use in the solution of exponential functions similar to the B.O.D.-time relationship and the oxygen-sag curve. The uses of such a computer in the field of stream pollution control are presented.

1851. ADMINISTRATION OF AIR POLLUTION CONTROL LAWS IN OREGON, BY RICHARD E. HATCHARD (SA) This paper presents the background of the Oregon Air Pollution Authority and its relationship with local agencies. Prevention and current needs as well as the role of the engineer are reviewed

1852. MUNICIPAL COMPOSTING IN THE UNITED KINGDOM, BY C. A. GORDON. (SA) Two municipal composting plants operating in the United Kingdom are described. The general trend in refuse disposal is outlined.

1953. SED RESEARCH REPORT NO. 21. SANITARY LAND FILL TESTS INVESTIGATING REFUSE VOLUME REDUCTION AND OTHER PHENOMENA, BY THE SOLID WASTES ENGINEERING SECTION OF THE SANITARY ENGINEERING RESEARCH COMMITTEE. (SA) The results of tests made to ascertain compaction, settlement, fill temperature, and gas production are presented. These data are reviewed with reference to obtaining optimum refuse disposal volume into a given landfill area.

1954. DESIGN OF PIER BENT AND RIGID FRAME, BY CHARLES P. C. TUNG. (ST) This paper presents the procedure of using moment distribution in the design analysis of pier bent or rigid frame by electronic computation. Sample solutions from the completed program, coded for the LGP, are illustrated.

1855. DISCUSSION OF PROCEEDINGS PAPER 1463, 1592, 1608, 1612, 1678, 1714, 1717. (SA) A. L. Danis closure to 1463. Remig A. Papp, Frank P. Coughlan on 1592. John W. Hamblen on 1608. Quintin B. Graves and Don Branscome closure to 1608. Gordon E. Mau on 1612. John R. Thoman on 1678. Harvey F. Ludwig on 1714. Thomas R. Camp on 1717.

1856. DISCUSSION OF PROCEEDINGS PAPER 1198, 1450, 1451, 1452, 1453, 1528, 1530, 1582, 1588, 1661, 1663. (HY) J. C. Stevens closure to 1198. J. M. Robertson on 1450. C. O. Clark on 1451. J. L. H. Paulhus and J. F. Miller closure to 1451. Donald P. Thayer on 1452. Robert B. Jansen closure to 1452. M. R. Carstens closure to 1453. A. J. Peterka and J. N. Bradley on 1528. James M. Robertson on 1528. Donald R. F. Harleman on 1528. Philip G. Hubbard on 1528. R. J. Garde and M. L. Albertson on 1530. D. C. Bondurant on 1530. John L. Bogardi on 1530. Marvin J. Webster on 1582. Quintin B. Graves and Don Branscome on 1588. E. Shaw Cole on 1588. Claud C. Lomax on 1588. H. Alden Foster on 1661. Gordon R. Williams on 1663. H. Alden Foster on 1663.

1857. DISCUSSION OF PROCEEDINGS PAPER 1353, 1355, 1356, 1562, 1567, 1630, 1631, 1633, 1636, 1637, 1638, 1696, 1710, 1722. (ST) James Chinn closure to 1353. Edward Cohen and Henri Perrin closure to 1355. Edward Cohen and Henri Perrin closure to 1356. Alexander Dodge corrections to discussion. Lembit Kald on 1567. Frederick H. McDonald on 1630. Victor R. Bergman on 1631. Octave W. Imer on 1633. Winfield H. Eldridge on 1636. John Reno on 1637. Yves Nubar on 1638. Zdenek Sobotka on 1638. I. Chen Chang on 1638. George W. Housner on 1696. Herbert S. Saffir on 1710. Dronnadula V. Reddy on 1722.

1858. DISCUSSION ON PROCEEDINGS PAPER 1697. (SU) William A. White on 1697.

DECEMBER

Journals: Hydraulics, Soil Mechanics, Structural, Professional Practices, Waterways and Harbors, City Planning, Power, Irrigation and Drainage.

1859. Meteorological Aspects of Storm Surge Generation, by D. Lee Harris. (HY) A hurricane model which describes the pressure and wind distributions, suitable for use in huricane storm tide studies, is presented. Statistical relations between hurricane intensity and extreme tide heights are given.

1860. A Method of Financing Ground Water Replenishment, by Howard W. Crooke. (IR) A program of financing ground water replenishment by a dual tax structure that provides the major source of revenue is outlined in this paper.

1861. Statewide Water Planning, by Harvey O. Banks. (IR) This paper examines the importance of long-range planning in the development of water with particular reference to water development in California.

1862. Model Approach to a Ground Water Problem, by Kenneth R. Wright. (IR) When adverse field conditions preclude a direct field investigation of a ground water problem, models can be utilized to advantage to determine directions of flow, velocities, location of hydraulic divides, and to forecast conditions which may occur in the future.

1863. Settlement of Oil Storage Tanks, by Andrew W. Braswell, Jr. (SM) A review of the actual settlement of steel storage tanks with a description of the soil conditions at each tank is given. Construction procedures employed to improve foundation conditions are described, and a comparison is made of theoretical and observed settlements for the particular area.

1864. Design and Construction of the Ambuklao Rock Fill Dam, by E. Montford Fucik and Rooert F. Edbrooke. (SM) The problems of designing and constructing a vertical-core rock fill dam are described in this paper. Records of settlement and seepage after operation at maximum reservoir level bear out the adequacy of design and construction procedures.

1865. Biaxially Loaded Reinforced Concrete Columns, by Kuang Han Chu and Algis Pabarcius. (ST) A numerical procedure is developed to determine the actual stress and strain distribution of a tentatively selected reinforced concrete section subjected to a given compressive axial load and bending moments in both directions about principal axes. The investigation is based on the ultimate strength theories of Jensen and Hognestad.

1866. Inspection and Tests of Welding of Highway Bridges, by John L. Beaton. (ST) The inspection techniques developed by the California Division of Highways for the control of the fabrication of welded highway bridges are examined. The use of radiography and other forms of nondestructive testing is outlined with special emphasis on the standards used to interpret the radiographic film.

1867. Direct Design of Optimum Indeterminate Trusses, by Louis M. Lausney. (ST) A direct design method is proposed for indeterminate trusses. The maximum possible compatible stresses are obtained for the bars. Redundant reactions and bar forces are selected to yield the minimum weight truss. Final bar areas then follow directly. Simultaneous equations and trial analyses are avoided. Design is emphasized, not analysis.

1868. Six Thousand High School Students View Engineering and Scientific Careers: Report of the Student Activities Committee, San Diego Section, ASCE. (PP) Our national professional engineering societies have expressed concern over

the engineering student shortage in our country. As a means of investigating the reasons for this shortage, a questionnaire was prepared. This paper presents the results of these questionnaires.

1869. Engineering Education as it Affects Unity in the Profession, by Frederick G. Lindvall. (PP) The present departmental educational pattern tends to exaggerate differences among fields of engineering and obscure for the student the common objectives and substance of engineering. Technological trends and the basic character of the appropriate education is examined.

1870. Pity the Poor Professors?—or Propagate Them!, by Jack McKee. (PP) The need for expanded and improved faculties of engineering is examined. Also considered are methods for retaining outstanding young engineers in the academic community, and action that can be taken by ASCE members.

1871. Importance of Emphasis in Civil Engineering Education, by L. E. Grinter. (PP) The tendency of new engineering students to choose electrical or aeronautical over civil engineering is explained by greater emphasis upon fundamentals of science and mathematics in these curricula which prepare their graduates for work on the frontiers of technology. A curriculum is presented for modernizing civil engineering education.

1872. Sputniks, Flopniks, and Engineering Education, by C. Ken Weidner. (PP) If we are to survive as a nation, we must produce creative thinkers, especially in science and engineering. Strong recommendations for achieving this goal are presented.

1873. Vertical-Lift Gate Design for Ice Harbor Lock, by Howard M. Rigler and Edmund H. Chun. (WW) This paper presents design details of the downstream lift gate for the Ice Harbor lock and some of the problems encountered. Also presented are the major features of the lock as a whole.

1874. Columbia Basin Streamflow Routing by Computer, by David M. Rockwood. (WW) A method for using a digital computer for streamflow routing in the Columbia Basin is described. A new routing technique is made possible by use of the computer.

1875. Financing of Sand By-Passing Operations, by Stephen R. Middleton. (WW) This paper presents information on the financing of twelve sand by-passing operations. Possible trends in the financing of work of this kind is considered and information is given on the problems and procedures in financing sand by-passing projects at various governmental levels.

1876. Motion of Sand Between Groins, by Shoshichiro Nagai and Hirokazu Kubo. (WW) Experiments on the motion of sand particles between groins were performed in a fixed basin to compare with the results of groins in a movable bed. The comparison proved that both results were in comparatively good agreement.

1877. City Planning Education for the Civil Engineer; Progress Report of the Committee on Education of the City Planning Division. (CP) The role of the city planner is essential in this era of expanding urbanization in which the problems of city planning and the need for trained city planners is receiving increased attention. Good opportunities for employment exist for those with training in principles and practice of city planning.

1878. Review of Limit Design for Concrete, by C. W. Yu and Eivind Hognestad. (ST) The development of limit design of reinforced concrete structures and various theoretical approaches are reviewed. Codes of practice of countries recommending limit design are quoted. The importance of incorporating limit design into future United States practice is stressed, and approaches toward this aim are suggested.

PROCEEDINGS PAPERS

The technical papers published in the past year are identified by number below. Technical-division sponsorship is indicated by an abbreviation at the end of each Paper Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Pipeline (PL), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways and Harbors (WW), divisions. Papers sponsored by the Department of Conditions of Practice are identified by the symbols (PP). For titles and order coupons, refer to the appropriate issue of "Civil Engineering." Beginning with Volume 82 (January 1956) papers were published in Journals of the various Technical Divisions. To locate papers in the Journals, the symbols after the paper number are followed by a numeral designating the issue of a particular Journal in which the paper appeared. For example, Paper 1859 is identified as 1859 (HY 7) which indicates that the paper is contained in the seventh issue of the Journal of the Hydraulics Division during 1958.

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DECEMBER: 1449(HY6), 1450(HY6), 1451(HY6), 1452(HY6), 1453(HY6), 1454(HY6), 1455(HY6), 1456(HY6)[c], 1457(PO6), 1458(PO6), 1459(PO6), 1460(PO6)[c], 1461(SA6), 1462(SA6), 1463(SA6), 1464(SA6), 1465(SA6), 1466(SA6)[c], 1467(AT2), 1468(AT2), 1469(AT2), 1470(AT2), 1471(AT2), 1472(AT2), 1473(AT2), 1474(AT2), 1475(AT2), 1476(AT2), 1477(AT2), 1478(AT2), 1479(AT2), 1480(AT2), 1481(AT2), 1482(AT2), 1483(AT2), 1484(AT2), 1485(AT2)[c], 1486(BD2), 1487(BD2), 1488(PO6), 1489(PO6), 1490(BD2), 1491(BD2), 1492(HY6), 1493(BD2).

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JANUARY: 1494(EM1), 1495(EM1), 1496(EM1), 1497(IR1), 1498(IR1), 1499(IR1), 1500(IR1), 1501(IR1), 1502 (IR1), 1503(IR1), 1504(IR1), 1505(IR1), 1506(IR1), 1507(IR1), 1508(ST1), 1509(ST1), 1510(ST1), 1511(ST1), 1512(ST1), 1513(WW1), 1514(WW1), 1515(WW1), 1516(WW1), 1517(WW1), 1518(WW1), 1519(ST1), 1520 (EM1)[c], 1521(IR1)[c], 1522(ST1)[c], 1523(WW1)[c], 1524(HW1), 1525(HW1), 1526(HW1)[c], 1527(HW1).

FEBRUARY: 1528(HY1), 1529(PO1), 1530(HY1), 1531(HY1), 1532(HY1), 1533(SA1), 1534(SA1), 1535(SM1), 1536(SM1), 1537(SM1), 1538(PO1)[c], 1539(SA1), 1540(SA1), 1541(SA1), 1542(SA1), 1543(SA1), 1544(SM1), 1545(SM1), 1546(SM1), 1547(SM1), 1548(SM1), 1549(SM1), 1550(SM1), 1551(SM1), 1552(SM1), 1553(PO1), 1554(PO1), 1555(PO1), 1556(PO1), 1557(SA1)[c], 1558(HY1)[c], 1559(SM1)[c].

MARCH: 1560(ST2), 1561(ST2), 1562(ST2), 1563(ST2), 1564(ST2), 1565(ST2), 1566(ST2), 1567(ST2), 1568 (WW2), 1569(WW2), 1570(WW2), 1571(WW2), 1572(WW2), 1573(WW2), 1574(PL1), 1575(PL1), 1576(ST2)[c], 1577(PL1), 1578(PL1)[c], 1579(WW2)[c].

APRIL: 1580(EM2), 1581(EM2), 1582(HY2), 1583(HY2), 1584(HY2), 1585(HY2), 1586(HY2), 1587(HY2), 1588 (HY2), 1589(IR2), 1590(IR2), 1591(IR2), 1592(SA2), 1593(SU1), 1594(SU1), 1595(SU1), 1596(EM2), 1597(PO2), 1598(PO2), 1599(PO2), 1600(PO2), 1601(PO2), 1602(PO2), 1603(HY2), 1604(EM2), 1605(SU1)[c], 1606(SA2), 1607(SA2), 1608(SA2), 1609(SA2), 1610(SA2), 1611(SA2), 1612(SA2), 1613(SA2), 1614(SA2)[c], 1615(IR2)[c], 1616 (HY2)[c], 1617(SU1), 1618(PO2)[c], 1619(EM2)[c], 1620(CP1).

MAY: 1621(HW2), 1622(HW2), 1623(HW2), 1624(HW2), 1625(HW2), 1626(HW2), 1627(HW2), 1628(HW2), 1629 (ST3), 1630(ST3), 1631(ST3), 1632(ST3), 1633(ST3), 1634(ST3), 1635(ST3), 1636(ST3), 1637(ST3), 1638(ST3), 1639(WW3), 1640(WW3), 1641(WW3), 1642(WW3), 1643(WW3), 1644(WW3), 1645(SM2), 1646(SM2), 1647 (SM2), 1648(SM2), 1649(SM2), 1650(SM2), 1651(HW2), 1652(HW2)[c], 1653(WW3)[c], 1654(SM2), 1655(SM2), 1656(ST3)[c], 1657(SM2)[c].

JUNE: 1658(AT1), 1659(AT1), 1660(HY3), 1661(HY3), 1662(HY3), 1663(HY3), 1664(HY3), 1665(SA3), 1666 (PL2), 1667(PL2), 1668(PL2), 1669(AT1), 1670(PO3), 1671(PO3), 1672(PO3), 1673(PL2), 1674(PL2), 1675 (PO3), 1676(PO3), 1677(SA3), 1678(SA3), 1679(SA3), 1680(SA3), 1681(SA3), 1682(SA3), 1683(PO3), 1684 (HY3), 1685(SA3), 1686(SA3), 1687(PO3), 1688(SA3)[c], 1689(PO3)[c], 1690(HY3)[c], 1691(PL2)[c].

JULY: 1692(EM3), 1693(EM3), 1694(ST4), 1695(ST4), 1696(ST4), 1697(SU2), 1698(SU2), 1699(SU2), 1700(SU2), 1701(SA4), 1702(SA4), 1703(SA4), 1704(SA4), 1705(SA4), 1706(EM3), 1707(ST4), 1708(ST4), 1709(ST4), 1710 (ST4), 1711(ST4), 1712(ST4), 1713(SU2), 1714(SA4), 1715(SA4), 1716(SU2), 1717(SA4), 1718(EM3), 1719 (EM3), 1720(SU2), 1721(ST4)[c], 1722(ST4), 1723(ST4), 1724(EM3)[c].

AUGUST: 1725(HY4), 1726(HY4), 1727(SM3), 1728(SM3), 1729(SM3), 1730(SM3), 1731(SM3), 1732(SM3), 1733 (PO4), 1734(PO4), 1735(PO4), 1736(PO4), 1737(PO4), 1738(PO4), 1739(PO4), 1740(PO4), 1741(PO4), 1742 (PO4), 1743(PO4), 1744(PO4), 1745(PO4), 1746(PO4), 1747(PO4), 1748(PO4), 1749(PO4).

SEPTEMBER: 1750(IR3), 1751(IR3), 1752(IR3), 1753(IR3), 1754(IR3), 1755(ST5), 1756(ST5), 1757(ST5), 1758(ST5), 1759(ST5), 1760(ST5), 1761(ST5), 1762(ST5), 1763(ST5), 1764(ST5), 1765(WW4), 1766(WW4), 1767(WW4), 1768(WW4), 1769(WW4), 1770(WW4), 1771(WW4), 1772(WW4), 1773(WW4), 1774(IR3), 1775 (IR3), 1776(SA5), 1777(SA5), 1778(SA5), 1779(SA5), 1780(SA5), 1781(WW4), 1782(SA5), 1783(SA5), 1784 (IR3)[c], 1785(WW4)[c], 1786(SA5)[c], 1787(ST5)[c], 1788(IR3), 1789(WW4).

OCTOBER: 1790(EM4), 1791(EM4), 1792(EM4), 1793(EM4), 1794(EM4), 1795(HW3), 1796(HW3), 1797(HW3), 1798(HW3), 1799(HW3), 1800(HW3), 1801(HW3), 1802(HW3), 1803(HW3), 1804(HW3), 1805(HW3), 1806 (HY5), 1807(HY5), 1808(HY5), 1809(HY5), 1810(HY5), 1811(HY5), 1812(SM4), 1813(SM4), 1814(ST6), 1815 (ST6), 1816(ST6), 1817(ST6), 1818(ST6), 1819(ST6), 1820(ST6), 1821(ST6), 1822(EM4), 1823(PO5), 1824 (SM4), 1825(SM4), 1826(SM4), 1827(ST6)[c], 1828(SM4)[c], 1829(HW3)[c], 1830(PO5)[c], 1831(EM4)[c], 1832(HY5)[c]

NOVEMBER: 1833(HY6), 1834(HY6), 1835(SA6), 1836(ST7), 1837(ST7), 1838(ST7), 1839(ST7), 1840(ST7), 1841(ST7), 1842(SU3), 1843(SU3), 1844(SU3), 1845(SU3), 1846(SU3), 1847(SA6), 1848(SA6), 1849(SA6), 1850(SA6), 1851(SA6), 1852(SA6), 1853(SA6), 1854(ST7), 1855(SA6)[c], 1856(HY6)[c], 1857(ST7)[c], 1858 (SU3)[c].

DECEMBER: 1859(HY7), 1860(IR4), 1861(IR4), 1862(IR4), 1863(SM5), 1864(SM5), 1865(ST8), 1866(ST8), 1867 (ST8), 1868(PP1), 1869(PP1), 1870(PP1), 1871(PP1), 1872(PP1), 1873(WW5), 1874(WW5), 1875(WW5), 1876 (WW5), 1877(CP2), 1878(ST8), 1879(ST8), 1880(HY7)[c], 1881(SM5)[c], 1882(ST8)[c], 1883(PP1)[c], 1884(WW5)[c], 1885(CP2)[c], 1886(PO6), 1887(PO6), 1888(PO6), 1889(PO6), 1890(HY7), 1891(PP1).

c. Discussion of several papers, grouped by divisions.

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